GameViews: Sports Storytelling via Auto-generated Narrative Visualizations

ABSTRACT
The increasingly-popular usage of narrative visualizations has paved the way for the exploration of numerous interaction techniques between text and visualizations and their usefulness in various domains. In this paper, we have explored the potential of narrative visualization techniques in the basketball domain from a novel perspective wherein a visualization interface is designed to efficiently deliver the objective game information needed for creating basketball-game narratives. We present our visualization interface, GameViews, whose design is informed by an observation that was conducted to study how professional sportswriters construct game recaps as well as the results of a qualitative analysis performed using 40 professional basketball-game stories. GameViews is composed of four components: (1) an auto-generated annotated game flow chart, (2) a box score table that contains all the players and teams’ statistics, (3) a player stats chart with a temporal layout, and (4) a shot chart with a spatial layout. We conducted an evaluation of GameViews with 4 professional sportswriters and 6 basketball fans and compared their performance to that with the ESPN website. The sportswriters rated GameViews to be very useful for constructing basketball-game reports and a majority of all the participants preferred the GameViews interface to the ESPN website for quickly finding key statistics and events of a transpired game.

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H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous; See http://acm.org/about/class/1998/ for the full list of ACM classifiers. This section is required.

Author Keywords
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INTRODUCTION
Narrative visualization is a popular means to combine and communicate text and visualizations in a story-like fashion. Storytellers, such as online journalists from the New York Times and Washington Post, are increasingly incorporating visualizations into their narratives to reveal data stories. The development of narrative visualization has also led researchers to review its design space [16, 32], create authoring tools [17, 30], and study various design factors [2, 18, 25]. However, the potential of narrative visualization in the sports domain remains underexplored.

Sports journalists report stories for games that typically generate a large amount of data [26]. Visualizations are widely being used to aid writers to facilitate efficient and effective “visual information seeking” [33]. For example, ESPN 1 and CBS Sports 2 routinely present visualizations and box score tables to summarize the game and present statistical information (See Figure 1). Sportswriters rely heavily on these online systems to write “recaps” (i.e., short reports) for each game. Yet, these systems fall short in two ways. First, it is difficult to identify key events easily, such as a team’s largest lead in the game. Second, the visualizations offer little in way

1http://www.espn.com/
2https://www.cbssports.com/
of fine-grained analysis. For example, finding the relationship between a player’s shooting behavior and time would require referring to and making connections between multiple, potentially disconnected, visualizations.

In this paper, we considered the potential of narrative visualization in the sports domain to aid sportswriters to quickly extract statistical information in their construction of game reports/recaps. We developed a system called GameViews that is specific to the game of basketball. Visually, GameViews consists of four components: (1) an automatically generated annotated game flow chart, (2) statistical box score table for each team’s players and the two teams, (3) player stats chart with temporal layout, and (4) player shot chart with spatial layout.

We evaluated GameViews with 4 professional basketball game writers and 6 fans. We found that the participants were able to find statistical information more quickly in GameViews than when compared with the ESPN website. All but one participant preferred GameViews and they all found GameViews to be easy to use.

Our paper makes the following contributions:
- A report of an observation study conducted with a professional basketball writer describing the process of how a game recap is written
- A summary of the types of key statistical information commonly found in game recaps obtained by performing a systematic analysis of 40 basketball game recaps
- A novel approach for automatically generating annotations for a basketball flow chart
- A novel algorithm for placing annotations in a line chart
- The design and evaluation of two methods for annotating a basketball flow chart
- The design and evaluation of an interactive interface designed to aid sportswriters in writing basketball stories

RELATED WORK

Narrative Visualization

Storytelling enables visualization to convey information in a more effective way [9]. Narrative visualization that integrates storytelling into visualization design promises to advance visualization research from exploration to presentation [22]. To support such presentations, Segel and Heer [32] collected and examined 58 narrative visualizations and proposed a design space that included seven genres of narrative visualization. Hullman and Diakopoulos [16] proposed using “visualization rhetoric” to understand how storytelling affects users’ interpretation.

The proliferation of narrative visualizations has led researchers to study various aspects of visual narratives including the effect of narratives [2] and visual story flow [25] on user engagement [2]. It has led researchers to implement authoring tools for creating narrative visualizations [8, 26, 30], and to explore the effect of design factors on story reading experience [18, 20].

Annotating Visualization

Visual salience is vital for graph comprehension [13]. Narrative annotations support the process of perceptually understanding a graph by “graphically” guiding readers’ attention to visually salient features [32]. The text annotation incorporated in the visualization can also explain what the data means and it is especially important in journalism [4].

These findings inspired researchers to develop various systems for generating annotation for visualization. Kong and Agarwala [21] proposed graphical overlays that include text annotations to aid chart reading. Kandogan [19] introduced just-in-time descriptive analytics to automatically identify and annotate visual features to help users easily understand the structure of data. Hullman et al. [17] defined two annotation types in narrative visualization: additive (provide extra information) and observational (give context to data value or group in the visual representation). They developed an automatic system to generate text annotation for stock market timeline charts. Bryan et al. [3] further proposed an approach to create annotations for all temporal visualizations. Our solution differs in that we automatically generate textual annotations on a line chart in the sports domain with an emphasis on facilitating comparison and finding trends. GameViews also considers information specific to sport writers’ views.

Data-driven Sport Journalism

Data-driven journalism is the use of data in journalistic reporting [12]. The visual format of data-driven journalism is interactive information graphics, or visualization [34]. In recent years, online journalistic efforts including those at The New York Times and The Guardian are increasingly incorporating visualizations into their narrative stories [32]. Researchers have also developed visual systems to aid journalists in extracting insights from various sports. For example, Perin et al. [28] introduced SoccerStories to support expert analysis of soccer data and to support extraction of insights. Cox and Stasko [7] used a TreeMap representation to help discover meaning in baseball statistical data. Wu et al. proposed iTTVis for analyzing and exploring table tennis data. The design of our system is also informed by the use of visualization techniques to help journalists discover and communicate relevant insights.

Basketball Analysis

Statistical analysis has been widely used for basketball games. Oliver [27] first emphasized the power of quantitative analysis and proposed advanced metrics to evaluate the performance of players and teams. Hollinger [14] created PER (Player Efficiency Rating) to summarize a player’s statistical accomplishments in a single number. Researchers have used Markov chain models to predict NCAA basketball winners [23], developed trajectory-based approaches to model complex multiplayer behavior in a basketball game [29], analyzed spatiotemporal data that was generated from object tracking systems to predict near-term game events [35] and player movements, [5] and to understand the team’s overall performance [11].
Visualization methods have also been explored to communicate basketball game insights and present statistical values and events. Goldsberry [10] introduced an ensemble system, CourtVision, to quantify and visualize NBA players' shooting range. Beshai [1] developed Buckets to support viewing details of shooting behavior and to allow comparison of multiple players. Losada et al. [24] also developed interactive visualizations to allow immediate user feedback and help players and coaches gain insights. From a different point of view, Chen et al. [6] presented GameFlow to reveal NBA games at multiple levels including the season level, game level, and session level. In this paper, we integrated narrative visualization into our interactive interface with a focus on supporting journalist in writing basketball stories - which is inherently different from gathering insights in support of performance improvement.

**DESIGN REQUIREMENT ANALYSIS**

Our intention was to develop an interface to help sports-story writers quickly find the relevant statistical information needed to write their story. We began by conducting an observation study with a professional sports journalist to understand the process involved in the writing of a basketball game recap. We then conducted a systematic analysis of 40 basketball stories to characterize what types of game data are generally reported in such a recap in order to inform the design of our interface.

**Observation Study**

Prior research reports that sports journalists normally refer to box score tables or visualizations to find the necessary statistical information for writing their stories [15]. To confirm this argument and get a first-hand understanding of how professional writers construct their stories, we observed a professional sports journalist carry out this process of experiencing a game and writing the corresponding basketball recap. The journalist had 10 years of experience with sports-story writing. We first watched a college basketball game with the writer and observed his routine of constructing the story. After he submitted the story, we asked him some follow-up questions to glean more insights into how we can better support his process.

We divide the observed writing process into three stages. Before the game, the writer received a document that included the recent performance statistics of the two teams and all the players. He also built a simple template that included the layout of the article. During the game, the writer observed stats in real time through statBroadCast 1, a real-time stats tracker. He specifically paid attention to and noted the salient elements such as a big difference of field goals and a player’s career high score. After the game, the writer first wrote down the notes he took during the game, then he checked the box score table, play by play, and visualization charts on the ESPN website and statBroadCast to find additional interesting statistical insights. He then completed the story.

We present two design implications from the observation and interview:

- **Simple and familiar visual design** The writer told us that he usually has limited time to extract insights from the visual interface given the tight deadline. Hence he preferred a simple and familiar visual design that he could quickly explore and from which he could directly extract the facts he wanted.

- **Fine-grained analysis** The writer expected the interface to support a more fine-grained analysis. He said “I always include runs in the story, but I’d also like to know what happened in the run...” Therefore, some interactive visualization techniques that can help writers explore events, such as a scoring run, at a fine-grained level are needed.

**Characterization of Basketball-game stories**

To identify the common statistical information that basketball writers potentially include in their stories and to include those in the design of GameViews, we constructed a corpus of 35 basketball recaps from the ESPN website and 5 recaps from other local news websites. Specifically, the analysis sought to answer two questions: (1) What are the types of statistical information usually included in basketball sports stories? (2) What are the common key events described in basketball sports stories? In other words, we were interested in finding what kinds of objective information were contained in the recaps. The objective information can not only be found in the supporting visualizations but they also provide a base to the stories which are then shaped by writers by adding their perspectives and embellishments to create engaging recaps.

**Methodology**

40 recent basketball game recaps were compiled into a corpus (full list included in supplemental material). We noticed that Associated Press (AP) covers all the NBA and NCAA basketball games and multiple media outlets including ESPN publish the AP basketball game story as the game recap on their website. The majority (35/40) of this corpus were stories produced by AP news and published by the leading sports media outlet, ESPN. The remaining (5/40) came from heterogeneous sources such as posts from college media outlets and local news publications. The corpus covered all 24 NBA teams and 5 college teams. We also used game results as a criteria to capture a broad range of stories. Specifically, we included 15 games with a final score difference less than or equal to 5 points, 10 games with less than 10 points and greater than 5 points difference, and 15 games with greater than 10 points difference. We also included 3 games that went into overtime.

We referred to the coding process described in the paper by Hullman et al. [18] for qualitatively analyzing the basketball-stories. To extract and characterize the statistical content of the corpus, we individually reviewed a set of stories and summarized the characteristics found in them. Specifically, two coders first extracted and analyzed the statistical content in five stories, which resulted in the initial categories for all statistical information. Over several iterations, the coders refined the categories and identified a set of codes to represent them. Five stories were then coded independently by the two researchers and then the codes were updated to reconcile the differences between two coders. The remaining stories were then coded independently.

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1http://statbroadcast.com/
### Table 1: Statistic-related information categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Types</th>
<th>Example</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual player statistics</td>
<td>High player stats in the game</td>
<td>T.J. Warren scored a team-high 35 points in the game</td>
<td>40/40</td>
</tr>
<tr>
<td></td>
<td>High player stats in a certain</td>
<td>Lillard scored 19 points in the fourth quarter</td>
<td>28/40</td>
</tr>
<tr>
<td></td>
<td>period</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Personal career / season high</td>
<td>Elfrid Payton had a season-high 14 assists for the Suns</td>
<td>12/40</td>
</tr>
<tr>
<td>Team statistics</td>
<td>Team Lead / Leading changes</td>
<td>Memphis led 84-77 early in the fourth quarter, the biggest lead for</td>
<td>11/40</td>
</tr>
<tr>
<td></td>
<td>high</td>
<td>either team</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High team stats in the game</td>
<td>Phoenix finished with 33 assists and outscored the Hawks by 20 in the</td>
<td>19/40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>paint</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Team’s season high</td>
<td>Atlanta tied a season-high with 17 three-pointers</td>
<td>5/40</td>
</tr>
<tr>
<td></td>
<td>Short time run</td>
<td>Utah closed the first half on a 20-6 run stretching over the final 3:49</td>
<td>33/40</td>
</tr>
<tr>
<td>Key events</td>
<td>Points scored in crucial times, e.g.,</td>
<td>Lou Williams scored the last of his 21 points with a 15-foot jumper</td>
<td>13/40</td>
</tr>
<tr>
<td></td>
<td>final time</td>
<td>with 8.9 seconds left,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Final lead / tie in the game</td>
<td>the Cavs took a 115-114 lead with 2:40 left.</td>
<td>14/40</td>
</tr>
<tr>
<td></td>
<td>Particular plays in a run</td>
<td>Siakam’s fast-break layup finished off the run</td>
<td>21/40</td>
</tr>
</tbody>
</table>

**Characterization Results and Design Requirements**

As shown in Table 1, we summarized the statistical information that is commonly included in basketball game recaps into three categories: individual player statistics, team statistics, and key events. We present the design requirements that emerged from the characterization results below.

- **Individual / team statistics** Sportswriters always include statistical information such as highest scores and rebounds in their stories. In addition, we found that they were also interested in the details of players’ statistics. Thus our interface should assist writers in finding this information quickly and support exploratory analysis of the statistical information.

- **Run information** In basketball, a “run” corresponds to a time interval in which one team heavily outscores the other. The results showed the need for automatically identifying all the short-time “runs” in the game. The interface should also support sportswriters in examining the details of a run.

- **Key events** Sportswriters need to quickly find the key events (refer Table 1) in a game and the interface should provide context for those events.

**GAMEVIEWS SYSTEM**

Based on the design implications and requirements we acquired from our observation study and analysis of statistical information in professional basketball recaps, we designed a visual interface to support sportswriters in writing basketball-game stories. In this section, we discuss the system overview, user experience design, and the design of each visual component of the GameViews system.

**System Overview**

As shown in Figure 3, the system consists of a server component that collects and preprocesses relevant data from the ESPN website and a web-based interface that displays interactive visual representations. The web crawler collects all the shot data and each data point has various attributes including time, position, home-team score, away-team score, and a brief description. Based on the shot data, we generate all the necessary annotations and render a shot chart. The game flowchart is generated from the shot data and associated annotations. The web crawler also collects the play-by-play text data with each item including player, event, and time information. The text parser then generates all the detailed statistical data for each player. The player stats chart is generated based on the detailed statistical data including points scored, rebounds, and assists. We also generate the box score table for all the players and teams based on the statistics collected by the crawler.

GameViews is implemented in Python and JavaScript with the Flask framework. The web crawler is built with the Python BeautifulSoup library and the text parser leverages multiple NLP libraries including NLTK and the Stanford NLP coreNLP. The visualizations are built with the D3.js library.

**User Experience Scenario**

Figure 2 shows the GameViews interface for a game between two NBA teams: the Portland Trail Blazers and the Oklahoma Thunder. The interface includes four parts: an annotated
Figure 2: GameViews interface showing a game between two NBA teams: the Portland Trail Blazer and the Oklahoma Thunder. A) shows the annotated game flow chart where the grey areas indicate runs and red dots annotate team largest leads and lead changes. B) is a box score table that shows all the players’ statistic information. The table can be sorted by clicking the header of each statistic type. C) is player stats chart that shows all the home team’s shots (and type) over time. This chart is dynamically updated to show a player’s statistic information such as points or rebounds if the user clicks the corresponding stat header in the box score, B. D) is a shot chart that shows all shots spatially for both teams and can show individual player shots as well.

Figure 3: The architecture of the GameViews system. Users input an ESPN address of a game of interest. The server will crawl all the data and the client will then render all the visualizations.

game flowchart, a box score table, a temporal player statistical chart, and a player shot chart with spatial layout. Consider the following scenario for how a sportswriter would experience the interface.

Suppose Maria is a basketball writer who works for a local newspaper in Portland, Oregon. After watching the Blazers beat the Thunder tonight, she needs to submit a game recap for the newspaper’s website. She finds the game on ESPN and copies the ESPN URL. She opens GameViews, and pastes the URL into the search box. GameViews updates to show this game.

Figure 4: Some examples of the updated charts when interacting with GameViews. The upper left figure shows all the shots by Russel Westbrook from the Thunder. The upper right figure shows all the shots in the first run by the Trail Blazers. The bottom figure shows Russel Westbrook’s shots in the temporal player stats chart.
At first glance, she sees that it was a tight game with the two teams swapping leads several times during the game. The Blazers won the game with 108–100. She is interested in finding out what happened during the game, so she scans Figure 2 A and finds that the Trail Blazers came back from a big deficit with a 13:2 run at the beginning of the second quarter, then the Thunder tied the game with a similar run at the end of the second quarter. She wonders what happened in the Blazers’ run, so she clicks the first grey area corresponding to the run and sees the shot chart update to show the details of this run (Figure 4 upper right). She finds that in this run, the Thunder missed two 3-pointers and only made one shot in the paint area while the Trail Blazers made three shots. She noticed the Thunder led at the beginning of the game and the Trail Blazers dominated in the last quarter. She also finds after the final lead change at the middle of the third quarter, the Trail Blazers kept the lead and won the game. She wonders who took the shot that led to the final lead change, so she clicks the red dot, 1, and the note at the top of the flow chart shows “CJ McCollum makes 25-foot three pointer”.

Maria also wants to know who were the top performers in the game, so she goes to Figure 2 B and clicks PTS, REB, and AST to sort the table and find who led the Trail Blazers in points, rebounds, and assists. She finds Russel Westbrook led the thunder in scoring. She wants to see his shot distribution so she clicks his name in the table and sees the shot chart update to show the view in the upper left of Figure 4. The player stats chart also updates to show the bottom view in Figure 4. She finds Westbrook made most of his shots at the end of the fourth quarter and he did not take many 3-point shots. She can click the Team button to compare all detailed statistical performance of the two teams. As shown in the upper right view in Figure 4, she can also hover over any shot in the shot chart and player stats chart to see the description of a particular shot.

As such, GameViews has supported Maria in (1) immediately finding all the key events in the game; (2) quickly finding salient individual player and team statistical information; and (3) examining the details of each player of interest, the runs, and each quarter in the game.

POI Definition and Annotation Generation

A point of interest, or POI, is referred to as an annotation that describes a single aspect of the underlying dataset [3]. For example, in a time-series line chart, POIs may include the maximum and minimum points. In the basketball domain, we define our POIs as the annotations that describe the key events in the game. Based on the characterization results in Table 1, the POIs we collected for the game include the home/away team’s largest lead (and time of that lead), final lead change, and runs.

The largest lead and final lead change points can be easily extracted by iterating over all the shot data to compare the two teams’ scores. Here we defined a run over a maximum four-minute interval in which one team outscores the other by at least nine points. To extract the run information, we first built a score list for each team. Then we used a four-minute time window to scan the two lists and check if either team outscored the other by more than nine points during that window. We extracted all the eligible runs with each including the start time, end time, and team name.

Annotation Placement 1

Inspired by Contextifier [17] and TSI [3], we first designed an annotation-placement approach where we placed all the annotations on the temporal layout and use lines to connect them to the POI. It should be noted that we connected the two lines of the start and the end point of each run. We also connected all the nearby largest-lead POIs to avoid cluttering the display.

While the top-n ranked placement algorithm and density-based placement algorithm TSI [3] are designed for different scenarios, for our use case, we designed a novel placement algorithm to determine the positioning of the annotations on the game-flow chart. The basic idea behind the algorithm is to divide the visualization into a fine-grained grid, traverse the list of
events (with associated textual annotations) in temporal order and assign the unoccupied rectangle nearest to the event’s position on the grid to its corresponding annotation. This ensures that the annotations don’t overlap in the chart. The time complexity of the algorithm is \( O(n) \) where \( n \) is the number of events/annotations. The algorithm also allows the flexibility to change the denseness of the grid depending on the number of events identified. For example, our approach, shown in Algorithm 1, divides the visualization into a 10x4 grid.

**Algorithm 1**

An algorithm for annotation placement

```plaintext
Function Annotation_Placement(E)
  INPUT: a lists of event labels E where each element contains its x and y coordinates and text
  OUTPUT: a list of event label arrangements A
  Divide the visualization along x-coordinate into four equal parts:
  \( X \leftarrow x\text{-coordinates of the segment points from left to right}; \)
  Divide each part along y-coordinate into ten equal segments:
  \( i \leftarrow 0; \)
  for Each of the four parts do
    \( Y_i \leftarrow []; \)
    for Each of the ten segments do
      if \( j \) doesn’t contains the plotted lines then
        \( Y_i.push(j); \)
      \( i \leftarrow i + 1; \)
    for Each event element \( e \) of the event lists \( E \) do
      for Each value \( X[k] \) in \( X \) do
        if \( X[k-1] < x\text{-coordinate of } e < X[k] \) then
          \( A.e \leftarrow \) the segment in \( Y_i \) closest to \( e\text{'s coordinate}; \)
          Remove the assigned segment from \( Y_i; \)
```

**Annotation Placement 2**

Based on a JavaScript library called d3-annotation[^4], we implemented another annotation placement approach as shown in Figure 6. Run annotations were shown as grey rectangles without interfering with the lines. Other annotations were presented as “badges” to mark the POIs in the flow chart. This approach does not require a complex annotation placement algorithm since the only necessary information for each annotation is the time of the event.

Users can click the annotation to explore its details. For example, the upper right view in Figure 4 shows all the shots after the user has clicked the first run annotation.

**Box Score Table**

As shown in the two upper views in Figure 7, the box score table includes the players’ and teams’ statistical information. Users can click the head of the table to sort by each type of the statistic. To view fine-grained details, users can also click a player’s statistical data; the player stats chart will be updated to show the corresponding temporal information. For example, Figure 7 shows the player stats chart after the user has clicked Russell Westbrook’s rebound statistic.

**Player Stats Chart**

As shown in Figure 2 C, we chose a temporal layout to support the exploration of players’ statistical information. Each dot represents a statistical event such as a shot, rebound, or assist. Users can hover over the dot to examine the description of this event. We used the same color encoding with the two teams. As mentioned in section 4.2, the player-stats chart will be updated by selecting a statistical type in the box score table.

**Player Shot Chart**

As shown in Figure 2 D, the player shot chart includes all the shots in a spatial layout. Each dot represents a shot and users can hover-over the dot to examine the description of this shot. We used the same color encoding with the two teams. As mentioned in section 4.2, the shot chart will be updated by selecting an annotation in the game-flow chart or a player name in box-score table.

**EVALUATION**

We carried out a comparative user study to evaluate GameViews. While we developed GameViews with the goal of supporting sportswriters we were also interested in how GameViews could help basketball fans extract and explore the statistical information for a game. We chose to compare GameViews against the ESPN website since it is the most popular and commonly-used system for basketball writers and fans as well. As shown in Figure 1, the ESPN website includes statistical information in the box score and play-by-play and visualizations including a game-flow chart and shot chart. Specifically, in evaluating the GameViews system, we were interested in finding answers to the following three questions:

^4http://d3-annotation.susielu.com/
• Can GameViews help sportswriters and fans find objective game information more quickly than with the ESPN website?
• How do sportswriters and fans perceive the usability of GameViews system?
• Which annotation-placement approach is better in terms of visual saliency and which is preferred by sportswriters and fans?

The first question was the main goal of this study. To answer this question, we designed a set of statistical information-retrieval tasks. Specifically, our considerations for the task design were two-fold. First, we chose tasks that exercised all the elements of the GameViews interface. Second, we chose tasks that covered all the three categories of the characterization results and allowed us to gather feedback on a variety of usage scenarios. A full list of the study tasks can be found in the supplemental materials.

The game between the Trail Blazers and Thunder (Figure 2) was used as an example for introducing GameViews and the ESPN website to users. The game between the 76ers and Bucks was used for testing purposes.

We recruited ten participants, four professional basketball writers and six basketball fans who watched and followed basketball avidly. The four writers, two male and two female, had an average of six years of experience with writing basketball game stories. They regularly published their stories in newspapers, online websites, and blogs. Three out of the four writers and five out of the six fans normally used the ESPN website for checking basketball game statistics. One writer uses StatBroadcast and one of the fans uses the EuroLeague website. The study lasted 30 minutes for each participant and their interview responses were audio recorded. Each writer was compensated with a $20 Starbucks gift card and fans were given $15 each for participating in the study.

The general study protocol is described as follows. We asked the participants to fill out a pre-study questionnaire to collect demographic information. The main study consisted of six phases: learning software A, experiencing software A, testing software A, learning software B, experiencing software B, and testing software B. Software A and B refer to the ESPN website and GameViews interface, respectively, or vice versa. Finally, the participants were required to fill out a post-study questionnaire.

During the learning phases, the author walked the participant through the interface and introduced each part in detail. In the testing phases, the participants were asked to complete the given tasks. We recorded the time each participant spent on each task. During the learning phase for the GameViews interface, we also introduced the two annotation-placement approaches to the participants and instructed them to explore both of the approaches. Before the testing phase of GameViews, we asked the participants to rate the visual saliency and their preference for the two annotation-placement approaches. All the learning was done with the Trail Blazers vs. Thunder game and the testing was completed with the 76ers vs. Bucks game. The orders of the software, i.e. the ESPN website and GameViews, were counterbalanced to compensate for possible learning effects.

While we kept the study protocol largely the same for both the writers and fans, some procedures were slightly different. In the pre-study questionnaire, in addition to the demographic questions, we also asked writers about their experience with using statistical tools when writing a story. After the testing phrase for GameViews, we asked the writers to freely explore the GameViews system for an additional amount of time and reflect on the potential of using the system when writing basketball stories.

RESULTS

Annotation-Placement Approach 1 vs Approach 2

![Figure 8: Visual saliency rating for GameViews and ESPN website.](image)

After experiencing the GameViews system, all the participants rated the visual saliency of the two annotation-placement approaches. All the 4 writers thought approach 2 was very salient (3 out of 4) or salient (1 out 4). They all rated the visual saliency of approach 1 as neutral. All of the writers preferred using the annotation-placement approach 2.

For fans, 4 out of the 6 participants thought approach 1 was not salient-enough and approach 2 was very salient. All these four participants preferred approach 2. One participant rated approach 1 as salient and approach 2 as very salient, but he preferred approach 1. He said, "I like the design of approach 2, but I preferred approach 1 as it is more dynamic and I like to see text on the chart." The other participant rated approach 1 as very salient and approach 2 as salient, but she still preferred approach 2 for aesthetic reasons.

Task Completion-Time Comparison

All the sportswriter participants agreed that the test tasks were related to the statistical information they would like to include in their stories. As shown in Figure 9, the sportswriters completed the tasks in a shorter time with the GameViews system (Mean = 21.99s) compared with the ESPN website.

5 http://www.espn.com/nba/game?gameId=400975687
6 http://www.espn.com/nba/game?gameId=400975693
7 http://statbroadcast.com/
8 http://www.euroleague.net/
We developed GameViews with the purpose of supporting work. All the writers thought GameViews was either very easy (3 out of 6) or easy (2 out of 6) to use. They all preferred GameViews over the ESPN website.

The t-test showed that the difference in time was significant ($t = 4.58, p = 0.01$).

The above trend was also observed among the fans who completed the tasks more quickly with GameViews ($Mean = 21.138s$) than with the ESPN website ($Mean = 42.389s$). The t-test showed that the difference in time was significant ($t = 8.54, p < 0.001$).

**Usability of GameViews**

All the writers thought GameViews was either very easy (3 out of 4) or easy (1 out of 4) to use. Three of them said they would prefer GameViews to the ESPN website for future statistical-information-seeking. The other writer said he would prefer GameViews if the author could make some suggested improvements. Three writers said they highly agree (2 out of 3) or agree (1 out of 3) that “GameViews can help me easily and quickly find the statistical information I want when writing the story”. One writer rated it as neutral since he could not find historical information for both teams.

Regarding the fans, they stated that GameViews was very easy (4 out of 6) or easy (2 out of 6) to use. They all preferred GameViews over the ESPN website. All the fans said they highly agree (5 out of 6) or agree (1 out of 6) that “GameViews can help me easily and quickly find the statistical information I need after the game”.

**DISCUSSION**

In this section, we discuss our study findings, how the participants in our study perceived GameViews and its advantages, incorporating GameViews into the basketball-recap writing process, and finally, design limitations and ideas for future work.

**Advantages of GameViews**

We developed GameViews with the purpose of supporting sportswriters in writing basketball recaps. In the comparative study between GameViews and the ESPN website, we found sportswriter participants were able to find statistical information more quickly with GameViews. They all agreed that GameViews was easy to use and our system was preferred by writers over the ESPN website.

In the post-study questionnaire, we asked the writers what they liked and disliked about GameViews. The writers thought highly of the auto-generated annotations in the game flow chart. As a writer stated: *the annotation is definitely a good feature, I can envision the annotations will be super helpful for writing the stories, especially since we are always on deadline*. They were also impressed by the design of GameViews: *I like the one-page design, you can find all the necessary information in one page without going back and forth to scan other pages like ESPN.*

Another writer was intrigued by the interaction design of GameViews: *I like all the charts are linked together, especially if I want to know more about a player’s stats.* They also provided positive feedback for the temporal player stats chart: *I like the chart that shows the stats details when I click a player, I really need this when I want to see more about a player’s performance.*

GameViews demonstrates the benefits of using narrative-visualization concepts in sports storytelling. It is a tool designed to provide key game information to both sportswriters and readers alike. The game information provided mirrors the key types of information that writers typically mention in their game recaps and that readers are accustomed to reading in sports stories. These focal points are distilled and presented in a visually-salient fashion on GameViews without many of the extraneous interface elements and comments/text found on the ESPN website. This could be one of the main reasons why a majority of the participants in our study preferred using GameViews to ESPN.

GameViews can also be easily integrated into or combined with other systems focusing on basketball-game analytics. In the paper by Metoyer et al. [26], a text-visualization linking technique was demonstrated in an example context of a basketball-game visualization displayed on the ESPN website. Snippets of text from the game story are linked with their corresponding elements in the visualization. The GameViews interface can be combined with this linking technique whereby sportswriters, after writing their game recaps, “link” their story elements with the corresponding objective information in GameViews that they referred to in the process of constructing their recap. This can not only tie their stories with the data “evidence” but it can also potentially enhance the reader experience.

The concepts illustrated by GameViews can also be extended to other sports, such as soccer and American football, in which common visualizations used in the respective sports can similarly be used to present writers with the needed objective game information.

**Suggested Improvements**

Our users articulated several areas of improvement for the GameViews system. Two out of the four writers recommended integrating the two teams’ recent game results. *I like the team comparison table, but it would be great if you can also have the recent game results for both teams, so I can also compare the recent performance of the two teams.*
We aim to address the shortcomings noted above by incorporating the said features in the interface and by improving the interaction design to better highlight and call attention to important changes in the interface. Additionally, we only characterized 40 basketball stories to identify the most-commonly reported objective game information. While these stories were largely representative of typical basketball-game recaps, it may be possible to find additional types of information, such as players’ fouls, by characterizing a larger set of stories.

We observed only one sportswriter to characterize the process of writing basketball-game stories. While our interviews with the writer participants revealed that there is much similarity in their high-level processes of constructing game recaps, we are certain that there can also be many individual differences among their writing and game-information-extraction practices. Hence we plan to also study these individual differences by observing more sportswriters as they construct game recaps.

Sportswriters are the primary target users of GameViews. However, given the difficulty in recruiting participants from this specific user population, we were able to recruit only 4 writer participants. For future studies, we plan to recruit and study additional participants, both sportswriters and basketball fans.

Currently, GameViews only supports game visualizations obtained through the ESPN URL. Extensions can be developed such as a more user-friendly search tool that supports users to browse and search by team names and game results.

Given the recent effect of social media on sports journalism [31], an important avenue for future work is to explore how to improve the social and collaboration aspects of GameViews. A straightforward example would be supporting sharing of charts to social media.

Another promising avenue of future work is to make GameViews support real-time game-statistics analysis. The current version of GameViews only supports transpired games. Our observations and interview responses demonstrate the need for a real-time statistics-analysis system that the sportswriters can refer to concurrently while watching the game.

CONCLUSION
We have presented GameViews, an interactive narrative visualization interface to support sportswriters in writing basketball-game recaps. GameViews features an auto-generated annotated basketball-game flowchart that allows sportswriters to quickly identify the key statistics and events in the game. A comparative evaluation study showed that participants performed better with GameViews than with the ESPN website, a commonly-used site for checking basketball-game statistics, in terms of the speed of finding necessary game information, usability, and user preference.

REFERENCES


