...Not That They Win or Lose - But How You Watch The Game: Personalized Sports Viewing

by
M. Cristina Dolan, Jr.

Master of Computer Engineering Science
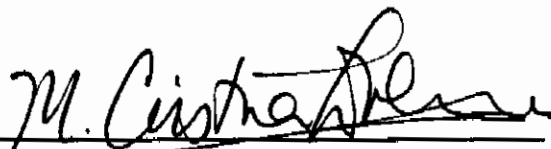Manhattan College, Riverdale, New York
May 1984

Bachelor of Electrical Engineering
Manhattan College, Riverdale, New York
May 1983

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning,
in Partial Fulfillment of the requirements of the degree of

MASTER OF SCIENCE
in Media Arts and Sciences
at the
Massachusetts Institute of Technology
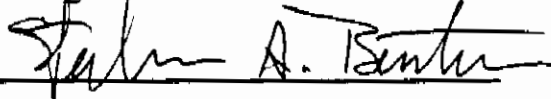June 1994

Signature of Author _____

M. Cristina Dolan, Jr.
May 6, 1994

Certified By _____

Walter Bender
Associate Director for Information Technology
Program in Media Arts and Sciences

Accepted by _____

Stephen A. Benton
Chairperson Departmental Committee on Graduate Students
Program in Media Arts and Sciences

...Not That They Win or Lose - But How You Watch The Game: Personalized Sports Viewing

by
M. Cristina Dolan, Jr.

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning,
at the
Massachusetts Institute of Technology
on May 6, 1994
in Partial Fulfillment of the requirements of the degree of

MASTER OF SCIENCE
in Media Arts and Sciences

Abstract

Technological advancements in the television industry have changed sports coverage dramatically since sports programs were first introduced on television in the 1940s, and will continue to change sports television as digital interactive television evolves. The ability to construct arbitrary and continuous viewing angles of an action event from a limited number of camera view points will dramatically change sports entertainment. The ideas that will be presented in this thesis will describe sports television programming when the capabilities of the new digital age are available for sports television. With digital television, viewers will be able to choose the viewing experience, participate in the experience or select the type of filler material between action events. The scope of this thesis will be constrained to investigating the creation of the Synthetic Transition Shot for continuous viewing angles for track sports, e.g. bobsled, and transitions for video games. There are four degrees of complexity to creating the Synthetic Transition Shot: determining the parameters which define the shape of the track, creating the model of the track from the parameters, merging the model of the bobsled onto the model of the track to synthetically create the action which takes place during the transitions between cameras and merging the synthetic and real footage seamlessly. Bobsled video footage is used in this research because of the geometry and texture of the bobsled and the track, but this research is applicable to other track sports, as well as, video games which transcend from real footage to a synthetic game environment.

...Not That They Win or Lose - But How You Watch The Game: Personalized Sports Viewing

by
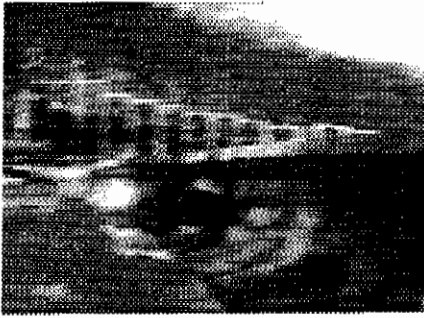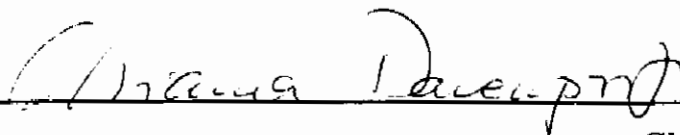
M. Cristina Dolan, Jr.

The following people served as readers for this thesis:

Reader _____

Glorianna Davenport
Associate Professor of Media Technology
ABC Career Development Professor of Media Technology
Program in Media Arts and Sciences

Reader _____

Aaron Bobick
Assistant Professor of Computational Vision
Program in Media Arts and Sciences

Table of Contents

Section III

Acknowledgments

References

Preface

'You can observe a lot by watching.'
Yogi Berra

As an avid golfer and as an active member of the U.S. Bob-sled and Skeleton Federation I have been both a participant and an observer of sports. The objective of my research is to attempt to make the experience of observing a sport almost as exciting as participating in the sport.

Section I   Sports and Media

1.0 Overview

Over the next decade as television programming shifts from traditional broadcasting into the digital era, the opportunities to create customized television programming will explode, both for the Producer as well as the televiewer.[1] Digital video databases will allow televiewers to select movies on demand, but movie selection alone is not enough to satisfy user preferences and does not fully utilize the power of the digital technologies. Through the use of an intuitive interface and an intelligent set-top device to select viewing material and manipulate programming, televiewer preferences can be more closely matched. It is important to note that televiewers will not be the only beneficiaries of this new powerful digital era. Sports Television Directors will also benefit from the greater flexibility which will be available through this new powerful digital medium.

In the category of sports programming, a sporting event can be presented in several ways depending on the objectives of the televiewer or Producer but the presentation does not

---

1. **Televiewer** is one who watches television.

change the outcome of the event, just the televiewing experience. The objectives for televiewing may range from the need to experience the thrill of speed, as in bobsled, to the desire to learn a sport such as golf. It is the viewing objective that will determine how the action segments of the event are customized for presentation on an individual basis. Creating a continuous viewpoint during the action portion of the sporting event or for instant replay will be the focus of the research that will be done in support of the ideas presented in this thesis. Bobsled will be used to explore this problem because of the geometry of the bobsled and the texture of the bobsled track. The research presented in this thesis is applicable to other track sports where the viewing angle is switched and the 180 degree rule[1] is broken, causing a discontinuity in the viewing experience. The Synthetic Transition Shot[2] was developed as a way to get

Figure 1.1

Figure 1.2

Figure 1.3: When Figures 1.1 and 1.2 are presented in sequence, the viewer assumes the characters are facing each other as in Figure 1.3.

---

1. The 180 degree rule defines the perspective, with respect to an axis which is perpendicular to the camera, from which the camera is looking at a particular event. For example, if we want to create the illusion that two characters are having a conversation, each character could be filmed separately, one character facing the left and the other the right. The viewer would assume the people are facing each other. If the camera cuts to a viewpoint from the opposite perspective, or 180 degrees around the subject, the viewer becomes confused and disoriented because the relative positions of the two characters have been reversed [Bor90].

around the 180 degree discontinuity by synthetically creating a segment of footage that connects two segments which are shot from opposite angles.

Organizing and presenting the filler portion of the sports program, which traditionally gets inserted between the action segments of the sport, is important to the viewing experience since it is traditionally used to give meaning to the action portion of the event. When Dan Jansen competed in the 1994 Olympic Speed Skating event, televiewers had a strong emotional reaction to his athletic performance because they were aware of the human drama surrounding the event [Cra94]. Features were presented by the media to inform televiewers of the entire Jansen family saga, including the anniversary of the death of Dan's sister on the day of the 1988 Calgary Olympics, the numerous unsuccessful attempts Dan had made for an Olympic gold medal, all the sacrifices that were made to get to the Olympics, and the birth of his baby, setting the stage for the event. These stories were presented with the intention of emotionally mov-

---

2. The **Synthetic Transition Shot (STS)** is discussed in greater detail in the Part III where the results of the research are discussed.

ing the audience. When Dan finally won his well deserved Olympic gold medal for the 1000 meters event, tear ducts swelled. Without this filler, which prepared the audience for the emotional experience, it would have been just another race without the human drama of athletic competition.

It is through the use of filler material that the sporting event is put into the context of the story and gains meaning. By embedding the action into the context of the story, televiewers can be pulled into an event without a deep understanding of the rules or the difficulties and nuances of the sport. Since all televiewers may not want the story to be set up as a human drama, the filler could also consist of statistical and technical analysis. The narrative would be developed to meet the televiewer's preference.

The digital age increases the Director's ability to create different types of programming, by providing the flexibility to access the segments which are pulled into the final story. The Director is no longer constrained by fitting into a 47 minute window for an hour long show. The program can be as long or short as a televiewer wants it to be. The develop-

ment of an intuitive flexible user interface would be a requirement for the uninhibited creative process to take place. Theoretically, user modeling could be utilized to create programming which meets televiewer's requirements, but the design of this type of a system is beyond the scope of this thesis.

Interactivity in the digital age opens up the possibility for cross marketing. Interactive television shopping could occur spontaneously. At the point of heightened interest, the televiewer could select a particular item, like a ski jacket during a skiing event, and make an unsolicited purchase. Advertisers spend a lot of money creating an emotional illusion which will motivate potential customers, but may not last long enough to motivate the potential customer to drive to the store and make the purchase. Taking advantage of the heightened state of emotion that a televiewer feels during a sporting event, may be a more effective way of selling products. Sporting events are heavily sponsored by sporting goods manufacturers [Vog92]. Why not provide interactivity which taps this emotional response potential, instead of disrupting the story with an unsolicited commercial?

Home exercise video instruction could become far more effective with computed feedback, based on information received through sensors and image analysis. During an aerobics instruction, a pregnant televiewer-exerciser could be told to not jump as high because her heart is beating too fast. The program would know enough to present less strenuous exercises, and could encourage the televiewer to keep the correct pace. Another example of interactive instruction might be a golf lesson, in which the student's swing is examined through sensors measuring a shift in weight and image analysis. A biomechanical computation could determine that the fulcrum of the swing is off, causing the player to hit the ball with the club face open. The golf student would be presented with a visual image which would illustrate what is happening and recommend changes. As the student progresses, the analysis fine tunes the recommendations until the student is satisfied[1]. The average golfer is not going to play like Jack Nicklaus, therefore, adjustments for natural tendencies, level of experience, body type and

1. Biovision has developed a complex system to train golfers and baseball players, which uses little reflective dots placed in critical locations. The athlete is videotaped swinging. Through simple image processing, movement of the dots is calculated to analyze the swing.

height would be taken into consideration more effectively through a computational analysis. Even if instructors fully understand what students are doing wrong, they must still find an effective way to communicate the action that each of the students understand. Keeping one shoulder down could be interpreted and executed as a physical action, by the student, in several ways. Communication of required movements would be far more effective when watching a video tape. The average person's perception of how they move their body may not be accurate, therefore, verbal instructions may not be executed properly. When change is incorporated in a physical action, the feeling may be that the action is exaggerated because there is a strong focus on the action, when in fact the action may not be exaggerated at all. Visual feedback provides the student with the ability to correct the error in their perception, while adjusting their

golf swing. Proprioception[1] could be more effectively developed through feedback to the human visual system.

Competing against athletes in a sporting event through electronic games could be a part of the sports entertainment of the future. A simulated bobsled event could allow televiewers to participate in the competition. Televiewers would interact through a game interface. At the end of the game, the televiewer's results would be compiled with the real competitor's scores and included in the official results of the competition as it appears on the television. If the player wins they would be able to see themselves on the podium while their national anthem plays in the background.

In the simulated golf environment, the televiewer could decide which professional foursome to join. Actual footage of the professional golfers would show when the profes-

---

1. **Proprioception** is the ability for the proprioceptors in the human body to monitor changes in the body.
Proprioceptors are the sensors in the muscles and joints, which sense the length and tension of muscles and the angles of joints. They are critical in providing state information to the motor system of the human body.
Together with vision and the vestibular apparatus in the ear, this makes up the system for human physical control [Cor93].

sional players are playing in a particular tournament. As the televiewer, who is playing with his special golf club with built in sensors, addresses the golf ball to take his turn the simulated environment would appear. Televiewers could also choose to play with neighbors and take turns playing and watching their neighbors play in the simulated environment.

Gambling would be a natural application for interactivity, but unfortunately televised gambling is still illegal [Man94]. Gambling has played an important role in history. 'The sailing of the Mayflower to the New World, the colonial army that helped create the United Stares, and start up costs for great educational institutions including Harvard, Yale and Dartmouth were financed through lotteries [Vog90].' The revenues of interactive television gambling could be applied towards the development of the national telecommunications infrastructure. According to the **Gaming and Wagering Business Magazine** $3.5 billion in revenue was made in 1988 from legal betting on Off Track Betting, horse racing, dog racing and Jaialai. Illegal betting in 1988 totaled $3.6 billion in revenue for sports books, horse books and sports

cards. Although gambling through interactive television is technically feasible, there are many social implications that would need to be researched before implementing interactive gambling for sports.

This thesis is divided into three sections. The first section discusses what makes sports a captivating form of entertainment when compared to other forms of entertainment. The second section focuses on the role different media played in making sports as popular as they are today. Technology alone was not responsible. It was the utilization of the technologies to tell captivating stories about the sporting events that has made the difference. According to Bill Fitts,[1] 'sports television in the early years influenced television technology innovation more than Hollywood did.' Section three discusses one specific example of a digital age tool called the Synthetic Transition Shot, which was created in support of this thesis. The value of the Synthetic Transition Shot will come from using it to improve continuity in sports which take place on a track or to provide a transition into a

---

1. Bill Fitts was the CBS Executive Producer for the 1963 Army Navy Football Game, which was the first planned video instant replay for a sporting event.

video game from real video footage. The results and conclusions of the supporting research for the Synthetic Transition Shot are presented in this section.

2.0 Why Sports?

'The drama of the sporting event is authentic. There are real winners and losers, the sports performers - the athletes actually feel pain and elation.... mistakes induce tears... home runs can produce euphoria....fans become so emotionally involved in the games that they cheer on their heroes and perhaps boo their opponents....'We' the players and 'They' the players become inseparable actors in the same drama... [Rad 84]'

Few forms of entertainment unleash the emotions that can be witnessed during a sporting event like the Super Bowl or the Olympics. Within a short period of time, sports allow televiewers to vicariously experience a range of human emotions. When the athletes experience the 'thrill of victory or the agony of defeat'[1], the fans experiences the emotions as if they were participating in the event themselves. Barry

---

1. From the introduction to the ABC Wide World of Sports television program.

McPherson calls it the 'affective sport involvement [McP89].' Interviews and stories about the athletes magnify the emotional experience for the televiewer, and allow the human characteristics of the athlete to come through as the story unfolds. The plot for a sporting event is straight forward, and the score represents how the plot has been played out. The suspense comes from the unknown strategies, which the teams have developed and from outside factors which may effect the outcome of the event.

Television brings the experience of watching sports into the living room. Powerful telephoto lenses, instant replay and eye-catching graphics pull the televiewer closer to the action, allowing fans to experience the exhilaration of participating in a sport like skiing without having ever skied, or the sensation of speed without the risk of getting hurt. Being an athlete is not a requirement for the vicarious emotional experience of being a sports fan.

'Fan', a word derived from 'fanatic' truly describes the sports enthusiast [Sim89]. It is common to see a stadium filled with fans dressed up in team jerseys and waving ban-

ners, yet it would be abnormal to exhibit similar behavior when attending other forms of entertainment, such as the ballet. Wearing a tutu to the Ballet would be considered quite odd, no matter how emotional or moving the story may be to the audience.

3.0   Human Qualities in Sport

There is a fundamental human quality that relates to sports, making it a unique form of entertainment. People can tune into a game at half time, see the score and gain enough understanding of how each team is doing to produce emotional outbursts as they cheer for a particular team. It is rare that any movie or play will generate the amounts of emotional cheering one can witness while watching a game[1] with a group of people. Language barriers do not interfere with the experience, which is mainly visual. It is the only type of programming which can be shown in public places, such as in taverns, where the audio component cannot be heard and still enjoyed by the televiewer.

Every game has a hero. There is a winner and a loser, although there could also be a tie. Even if the favored team loses, there is still the eternal hope of optimists for the next game. The media develops the characters - athletes - and the

---

1. **Game** refers to participation and a gathering for fun, derived from an Old English and Teuonic term.

drama unfolds as the game evolves. The plot twists and turns as the players attempt to take advantage of the opportunities that present themselves. Fans scream out directions as if they have some control over the athletes [Rad89].

Sports are rooted in man's primitive need to survive, defend himself and his tribe, hunt, compete, gain victory while providing a sense of accomplishment, satisfaction and achievement. Through games man learned strategy and developed reflexes necessary for survival. The original sports were derivations of individual elements of warfare, and the skills necessary to compete were those of a good soldier. In colder climates, games were developed that kept the blood circulating keeping people warm. Primitive games, such as tug of war, were played to expel demons. One team represented the good forces and the other team the bad forces. Religion also played a big part in sports, especially at the first Olympic Games which were played in honor of Zeus, at the temple of Zeus at Olympia [Kie65]. Many of the sports that developed out of primitive faith and the need to survive are still prominent today, like boxing, wrestling, archery, row-

ing, fishing and sailing. In modern society, sports have taken the place of combat [Bra70].

The word sport was derived from the Latin word 'desporto, which literally means to carry away. Today people, both participants and spectators, are still being carried away from their sedentary lives by sports. It has become such an ingrained part of our existence that we even incorporate sports phrases in our daily language. 'Team player', 'bull's eye' and 'hitting below the belt' are a few examples where the metaphor of the sport illustrates a situation.

4.0　　The Athlete As The Main Character

Today, athletes are national heroes to many fans, but prior to the 1920's American heroes were not athletes, they were businessmen or statesmen [Bra70]. The media develops the athlete's public personality in the same way a character is developed in a movie or play. As the public gets to know the athlete, they become more interested in their activities as if they were a close friend. Since the media creates the athlete's public image, it is the media which controls the image the public gets to know. The better the athlete's character is developed, the closer the audience feels to the athlete. Knowing the athlete has overcome severe setbacks brings out the human side of the athlete to the audience [McP89].

During the Winter Olympics 1994, the media promoted the fact that it would be Dan Jansen's fourth and final attempt to earn a gold medal in Speed Skating. The sad story about the death of Dan's sister on the morning of his competition at the 1988 Calgary Olympics made the audience wonder if skating on the anniversary of this tragedy would affect his

performance. The media focused on his family and his baby and educated the public on the sacrifices that Dan and his family made to make it to the Olympics. When the event was televised, the whole world was rooting for Dan. Having set the World Record for the 500 meter Speed Skating event made Dan the favorite for the Olympic Gold Medal. Unfortunately, Dan made an error causing him to lose the lead in the 500 meter event, and cameras quickly turned to his family and friends in the stands, who were devastated. The televiewer felt the devastation along with Dan and his family. When Dan came back to win the gold medal for the 1000 meter event, the public felt the elation. Televiewers had tears in their eyes and cheered from their living rooms. In fact, so did the CBS television announcers who were reporting the action. Without these background stories, Dan Jansen's victory would not have been as meaningful or as emotional an experience for the televiewer [Loe94].

An early example of the media developing a character by telling the human side of the story took place in 1961. In a filmed for TV documentary, "On the Pole," 4 camera crews created a portrait of the race car driver, Eddie Sachs, as he

prepared for and competed in the Indianapolis 500.[1] This was one of the first examples in which multiple cameras were used to cover high speed sporting events which involved a relatively large track. During the race one camera man was situated in the center of the track for the sole purpose of covering Mrs. Sachs as she watched her husband from the stands. While the camera man grumbled at being so restricted, the strategy paid off when Eddie skidded out loosing all chance for victory that year. As the car smashed into the siding the editors cut to a terrified Mrs. Sachs, who did not know if her husband would walk away in one piece. The camera man missed the action of the car crash, but he did capture the human side of the tragedy which created tension in the narrative.

The public often feels so comfortable with the character of the athlete, which the media has developed, that they are fooled into believing that they can defend the athlete's honor or make condemning judgments solely on the personality traits presented by the media. Tonya Harding's alleged involvement in the attack on Nancy Kerrigan was fre-

1. Produced by Drew Associates in 1960 and '61.

quently debated based solely on the information presented by the media. There was no assumption of innocence before proof of guilt.

5.0   The Plot

It ain't over 'til it's over.'

Yogi Berra.

Few movies capture the undivided attention of the audience like the final moments of a close game. While watching a game, it is common to find people so completely absorbed by the television event that self consciousness and awareness of the outside world is completely lost. Rarely do sports televiewers think about how they look when screaming out directions to the television set, which is passively presenting the picture on the screen. It is rare that a movie will pull a televiewer into the deep level of subconsciousness which is often achieved when watching a good sporting event [McP89].

The plot in a sporting event is straight forward. Within the window of time that the event will be held, there will be a winner and a loser for that game. The media introduces the characters through television graphics and special feature stories, which define the human side of the event, what the

competitors are facing and how they are feeling. Even if the favored team loses, there is still a next time. There is still hope that the next game will be different. The scoreboard defines exactly where the plot stands. It is clear that certain results must be accomplished no matter how clumsy the player may look while doing it. There is always the chance that each team can win, and the televiewer is pulled through the event in suspense as the plot unfolds. Unlike a drama or a serial television program, the dramatic points of the sporting event plot make it possible for the favored team or 'the good guys' to win. Twists and turns in a drama make it difficult to return the plot to the starting point.

Death is a big component in dramas and changes the way the plot might unfold. Once the character in the plot has been killed, there is usually little hope of the character coming back to life. As in life, the characters in a drama move forward in time and face new situations and new hurdles. There may not be a next time, because once the movie ends the plot is over.

In sports, there is the loss of a title or a chance to win a title, but it only increases the drama the next time an athlete or a team is in the same position in a game. The parameters which make the sports story dramatic are not irreversible, since there is always the next time. The timeline for a sporting event is well defined, it commences at the beginning of the event and terminates at the end of the event.

Books, plays and movies which tell a story are completely dependant on the timeline, during which the story takes place. The challenges characters will face will be dependent on the position on that timeline. In sports the timeline helps identify patterns which often provide insight as to what could happen at the next game, e.g. who might be the stronger player, but the player is not totally confined by past history. The audience can still hope that the underdog of the event will perform above expectation and be victorious.

Leonard Koppett, in his book Sports Illusion, Sports Reality describes seven characteristics of sports which do not equally apply to fiction:

1. Comprehensibility
2. Continuity
3. Readability
4. Coherence
5. Hazard
6. Low Cost
7. Vicarious Experience
    a. violence
    b. triumph
    c. second-guessing
    d. patriotism

One additional characteristic should be added to the list, which applies when televised sports enters the interactive digital era, and the televiewers can participate in the event through integrated electronic video games:

8. Participatory and Naturally Interactive
    - in the electronic game environment the participant becomes a character

The plot in a sporting event is easy to comprehend. Knowledge of the rules is not essential to the ability to understand the plot of the event. The score defines how the competitors have done. The player's objective is clear, they must score another point or move faster or be more accurate. How the plot unfolds will determine the televiewer's impression of the game.

The continuity of acceptance and understanding comes from the history of a team and the players. Predictions and comparisons can be made, but there is always the chance to win. There is always a next time. When one reads a book or sees a play, one does not think of it in the context of possibilities for the future or a sequel; there is no hope for a next time.

There are many ways to tell a story in sports. 'The team won' is enough to get a fan excited [Rad89]. Statistics and stories about the players can add to the televiewer's enjoyment of a sport. Stories are written about all aspects of sporting events. The line between real and fiction does not

exist. This allows the sports story to continue beyond the boundaries of the arena. The fans can get to know the event through the media and the athlete becomes a human character. Each day newspapers are filled with these types of stories because the public interest in such stories helps sell newspapers, even during the off season. Baseball writers have coined a phrase for the phenomenon, the 'Hot-Stove League.' The interest in 'Hot-Stove League' baseball information usually exceeds the interest in all other sports that are in-season, with the exception of the Super Bowl and the Olympics [Rub94].

The coherence of the story comes from the first three items on Leonard Koppett's list. Sports are a 'tight, closed and reliable system' for repeatedly producing interesting stories. History may allow people the ability to predict the outcome of an event but there is always some degree of uncertainty that keeps the public interested.

There are few hazardous experiences in modern life, even though there are many dangers around us. Yet the need to feel danger and risk has been a strong instinct in human

behavior, and is linked with the need to survive. There is a thrill associated with the feelings of danger and risk which can be experienced vicariously [Lap89]. The illusion of disbelief is easier to create in a sport, than it is in a drama or play. Once a sport is known for creating the suspended illusion of disbelief, the association with the sport does not go away the next time there is a similar sporting event. During the 1960's, television viewership for the staged violent sports like boxing and wrestling declined due to the increase in more realistic violent television series like Gunsmoke [Rad84]. The audience began to realize that the hazards of boxing and wrestling were staged and unrealistic, removing the illusion of disbelief. Research shows that people like watching hazardous sports programs, such as car racing and bobsled where there is a possibility for an accident. Demolition Derby, a sport were cars intentionally run into each other, was invented specifically to satisfy the audience's need to see accidents [Hic92].

The purpose of staging or broadcasting an event is to attract an audience. Based on the number of fans, a certain amount of revenue can be expected from the selling of advertising.

Since advertising is a big component in the economics of sports, recuperation of costs can be predicted far more effectively than other forms of entertainment, like movies [Gor94]. For the sports enthusiast, there are many forms of sports entertainment. Television makes sports available to televiewers all day through sports networks like ESPN[1] and the sports channels.

The vicarious experience is one of the most important facets of viewing experiences. As modern civilization has removed violence from the average person's life, sports has become an outlet by which televiewers can experience pain and intensity vicariously. The experience of watching a game can be quite physical for the televiewer, who identifies with the competitors. On a secondary level there is the vocal expression that is characteristic of fans during an event. In our daily lives one can emotionally feel like they are pushing ahead trying to accomplish some goal, yet in sports we see this accomplished though simple physical strength. Blood, sweat and tears are experienced by the tele-

---

1. ESPN was the top rated cable programer in 1988 and has recently developed ESPN2, which demonstrates the demand for televised sports programs [Vog92].

viewer through the actions of the competitor. The televiewer enjoys the emotion of the experience without the physical danger [Fis76].

As we move into the digital age, interactive television will allow televiewers to pull themselves into the experience while they sit in their living room. They will be part of the game since their electronic participation in the event will allow televiewers to affect their own outcome. As an electronic competitor, the audience can become a part of the story giving them control. The Synthetic Transition Shot could be used to enable electronic competition by the televiewer by enabling the transition from the real events to the synthetic environment where the televiewer competes with the real athletes.

Section II   Evolution of Sports Storytelling - Influenced by Technology

6.0   Introduction

The evolution of sports and media have created a unique mutual dependency. Sporting events require media focus to attract fans and sponsorship, while newspapers sell just by covering the sporting events. No other relationship of this kind exists in the media industry.

The introduction of new media technologies have improved storytelling in sports, but it is not technology alone that has improved the story. Understanding how to utilize the new technologies to improve storytelling is far more important to the success of the medium than just the capabilities of the technology alone. In the same way, inventing a new pigment does not make the painter a great painter; it is understanding the utilization of the new pigment in a painting to communicate a thought or idea that makes the painter great.

7.0   Media Tells the Story

7.1   Before Newspapers

The story of the first Olympic event, which took place in Greece in the year 776 B.C. was captured in history by the media of that time. The athletes and their accomplishments were immortalized by both poets and sculptors, who created the most influential forms of media of that era. The winners were more than heroes, they were considered idols. The stories represent these events as they were viewed within the context of their beliefs. The Greeks had strong religious beliefs, a reverence for beauty and admiration for athletic performance which were all tied together in telling the stories of events which took place in Olympia. It is difficult to separate what actually took place from the religious interpretations of what occurred. Beliefs strongly influence the perception of how an event transpires, perception seems real for the person who experiences it. The mythical method of storytelling, which is apparent in the culture of the ancient Greeks, is reflected in the communication of historical facts that occurred at that time [Kie65].

7.2   Newspapers

In the early 1800's sporting events were not news. The society classified sections of a newspaper might contain an advertisement or notice for a particular sporting event urging people to attend the 'spectacular event.' It wasn't until newspapers realized that sports helped increase readership that sports became a part of the news. Newspapers began to sponsor sporting events to increase circulation, and the reporting of the accounts of games provided the newspaper with additional promotion to support their sponsorship. Sports were events people wanted to hear about, and by increasing the frequency of the events, the newspapers were able to give readers one more reason to buy the newspaper, and buy it more often. Even politicians realized the power of sports, and began to participate in the celebration of sporting events to draw votes from the limelight of the events [Kop81].

The weekly journals which covered sports prior to the 1890's included **The New York Clipper, The National Police Gazette, The Sporting News,** and **The Spirit of the**

Times. The earliest widely circulated sporting journal was William T. Porter's **Spirit of the Times**, which started in 1831 as a weekly publication and by 1856 had 40,000 subscribers throughout the United States. Unpaid authors from all over the United States contributed articles on sporting events and games making it the record keeper for sports in America in the mid 1800's [Rad84] [Mit76].

In the late 1800's, it became apparent that sports increased newspaper circulation, therefore, newspapers began sponsoring and promoting sporting events. The owner of **The New York Herald**, James Gordon Bennett, Jr., began awarding medals to intercollegiate track and field champions. Richard Kyle Fox, publisher and editor of the **National Police Gazette**, offered championship belts and prizes for heavyweight boxing, female weightlifting and bizarre sports such as teeth lifting, hog-butchering, and one-legged clog dancing. The strategy proved to be successful since subscription numbers reached 150,000 by the mid 1880's and each copy was read by several people [Rad84].

By the 1920's, the larger metropolitan newspapers began promoting sports programs such as the Golden Gloves sponsored by **The Chicago Tribune**. By 1955, 25,000 competitors auditioned to become one of the eight Golden Glove finalists. **The Chicago Tribune's** legendary sports editor, Arch Ward, played a big role in promoting sports by organizing the All-Star Baseball Game in 1933, the Annual College All-Star Football Game in 1934, and many other sporting events [Kop81].

Sports writing evolved as it became more popular. Talented writers began to write articles which resembled the same style as news reporting. Different styles of writing were developed, exaggerated 'tall tales' which are the oldest form of sports stories, dramas which are closer to the truth and poetic verse which was popular in the early 1900's. Grantland Rice, who's quote inspired the title of this thesis, was one of the better known verse writers. The focus of the writers in the early part of the twentieth century was to weave the events into an interesting story. Reporting an accurate account of the facts was not the main objective. The tradition of portraying athletes as flawless heroes continued until

the 1960's, when modern writers were affected by the counter-culture of the era [Kop81] [Rad84].

Today, television and radio compete for the audience's attention to recount the story of a sporting event. Yet, sports are still a large part of the newspaper industry and the sports section of the news is the most time critical.

In the mid 1950's, magazines, like **Sports Illustrated** and **Sport** were created, which went one step beyond newspapers by capturing the moments of a sporting event with photographs and detailed articles. The public interest and thirst for knowledge about the many aspects of the game has made Sports Illustrated the most successful sports magazine with weekly circulation of 3.5 million in 1989 [McP89].

According to CNN Headline News, 84 sports magazines were started in 1993 alone, indicating the strong interest in sports stories. The increased coverage of sports by other media has not diminished the current interest in written sports stories.

8.0 Electronic Media

8.1 Radio

The demand for stories about sports grew with the catalyst of the newspaper industry, and radio prospered from this momentum. Sports fans would not have to wait until the following day to learn about the results of the games, since they could listen to the game the same evening over the radio [Kop81]. A new level of excitement was added to the sports entertainment experience by the audio intonations of the announcers.

The first radio broadcast of a sporting event, by a commercial station, took place on April 11, 1921. The event was a fight between Johnny Dundee and Johnny Ray and the sportscaster who covered the event was Harold Arlin. In July 1921, the RCA Radio Station, WJY in Hoboken broadcast the heavyweight championship fight between Jack Dempsey and Georges Carpentier to 100 locations, reaching 300,000 people. A relay system was used to create the broadcast. A blow-by-blow account of the fight was sent by

the ringside commentator, Major J. Andrew White, over the phone, to an engineer who broadcast the signal. The phone call was very expensive [Rad84].

By 1922 there were 60,000 radio receivers and 690 licensed radio stations. The radio stations were owned by newspapers, as public relations vehicles, and manufacturers of radios who wanted to create broadcasts which would sell radios. "Toll broadcasting"[1] was created to pay for programming, and although the use of advertising was controversial, it was finally accepted in the late 1920's. The first company to sponsor a major sporting event was the Ford Motor Company which paid $400,000 in 1926 for the rights to the World Series broadcast, which is what it will cost to buy just one prime 30 second television commercial during this year's World Series game[2] [Hof89].

---

1. **Toll-broadcasting** is used to describe typical advertising used in broadcast television and radio. The televiewer must pay the toll of watching the advertising before the presentation of the event continues.
2. The price of a 30 second commercial for the 1994 World Series will cost approximately $325,000 to $400,000 according to Harvey Rubin, President of Sports Television Management Inc.

It is amazing to think that phone calls were too expensive for sending the commentators' message from the sporting event to the radio station to be broadcast. Synthetic broadcasts or re-creations of the game were created at the station by reading the coded pitch by pitch plays, which were sent via telegraph by the Western Union operator at the park. Sound effects were improvised and added at the station in an attempt to make the broadcast sound as real as possible. By 1955 these recreations were banned by organized baseball, and from that point on, sports broadcasts were 'brought to you live from...', the location of the event[1] [Bro82].

It is interesting to note that the influence and involvement of existing media on the use of new media applies to radio as well. One of the first radio sportscasters was the well known sports writer, Grantland Rice. In a short amount of time new radio personalities evolved who mastered the ability to use the new medium to tell captivating stories about sporting events [Rad84].

---

1. Today's broadcast bandwidth, for both radio and television, is more constrained between the broadcasting station and the televiewer's television set. Large bandwidth is utilized between the event and the station to transmit high quality audio and video images.

9.0   Visual Storytelling

"Extraordinary experiences have always
intrigued people and the ability to enjoy
these vicariously has always been popular."
Jonathan Erland and Nora Lee, page 38, **The
Red Herring**, *Specialty Venues*, December
1993.

History has proven that new media takes the form of pre-
ceding media. The introductory use of film technology
developed from previous forms of visual performance. In
the early stages of the development of the film projector and
camera, the content was created by the equipment develop-
ers. A focus on the spectacular presentation of images and
vaudeville slapstick humor were the themes in the early
forms of content. Narrative film first evolved as a recorded
form of staged performances. Camera viewpoints were not
changed, the experience was similar to the viewpoint of the
audience sitting in front of the stage. As artists and enter-
tainers became involved in the process of storytelling on

film, the evolution of narrative films began to take place [Coo90].

Just as film was influenced by the previous mediums for communication and entertainment, film also influenced television and how the stories were told through the television camera. One example in the area of sports is Esther Williams, an Olympic swimmer, who starred in several films which featured synchronized swimming. The new techniques for filming synchronized swimming that were introduced in Esther's movies influenced the way swimming events were covered for sports television programming [Alc93].

10.0   Television

The first television telecast of a sporting event took place on the 17th of May, 1939. Columbia University played Princeton University in Baseball, on Columbia's Baker Field. Several hundred people watched at the RCA pavilion in New York. Orrin E. Dunlap, Jr. from **The New York Times** wrote: '...the players looked like white flies..........' It took 25 years from the first sports telecast to establish a standard method of live coverage, presenting the event to the televiewer in the same way the spectator saw it from the stands [Cla92].

10.1   Broadcast Sports

Technology alone did not improve the story that was told, it was the way that the technology was utilized to tell the stories that improved sports television.

In the early days of television sports, wrestling and boxing were popular because the story could be told within the constraints of the television lens technology available at that

point in time. In the early 1940's one, maybe two cameras were used to cover sporting events. The camera lenses were limited. The fixed field of view made it easier to cover sports which took place in an arena, like boxing and wrestling. Roller Derby[1] was invented in 1935 by Leo A. Seltzer to satisfy the audience's desire for action and violence, while fitting within the constraints of available television technology [Hic92].

---

1. Roller Derby made its debut on television in 1947 [Cla92].

11.0 Milestones in Television Technology

11.1 Lenses and Cameras[1]

One of the first camera lens systems used for televised sports was the four lens turret combination of lenses. The turret was flipped to switch lenses for different shots. The BACH Zoom was introduced in the early 1950's for daylight sporting events. Its lens speed was f 22. However athletes still resembled little flies or specks on the screen.

The Super Universal zoom lens, in use by the middle of the 1950's, had a 6 to 1 zoom and was 5 times faster, since it had an f 5.6 aperture. Extenders or multipliers which screwed into the backs of the camera lenses could be used to increase the power of the camera lenses, but slowed down the speed of the lenses by increasing the light requirement.

---

1. The information in this section is based on information from an interview with Clair Higgins [Hig94].

Lens extenders could only be used during the daylight hours.

The 10 to 1 lens introduced in the 1960's was more powerful, as well as 3 times faster, than the 6 to 1 industry standard.

Lens speed was just as important as the power of the lens, especially when shooting events at night. Clair Higgins recounted an event which he covered at the Hollywood Bowl in 1975. 'The 45 to 1 zoom lens was set up during daylight hours, the shot worked great, but the director wanted it at night. As the camera zoomed in from the last seat at the Bowl to a piano on the stage it gave the appearance of going to black. The cameras had to be moved further down into the stadium during the performance to get the planned tight shots. The problem was that the 45 to 1 camera had an aperture of f 2 for the wide shots, which reduced to an aperture of f 8 for the tight shots. The reduction in aperture caused a reduction in the amount of light entering the camera lens, which made the tight shots appear faded when the sun light was not available.'

Today the typical night lens at a sporting event might be a 55 to 1 lens or a 66 to 1 lens, and is capable of getting tight shots even at night.

In the late 1980's, solid state semiconductor chips were beginning to be used instead of vacuum tubes in cameras. The new camera CCD arrays which captured the image were smaller, faster and lighter than the vacuum tubes used in older cameras.

The development of small camera technology has added flexibility to how sports stories are captured. Lighter cameras make it easier for cameramen to move the cameras while following the action. Miniature cameras are imbedded in the equipment to give the athlete's point of view.

Jim Allegro, Executive Vice President of ESPN feels that new camera angles can attract viewership if they provide an interesting perspective, which translates into an increase in advertising dollars, especially if it is an award winning camera angle. One example was joy stick cam for a view from the goal posts during football games, which was imple-

mented by ESPN at a large expense because of the interesting perspective. The cameras had to be put on the goal posts at the beginning of each game and then removed at the end of the game. Control of the camera was done with a remote control joystick.

Helmet cameras have been used in football to bring the audience right down into the action. With helmet cameras in football, the televiewer can see what the player is facing on the field as the opponents come running towards him for a tackle. In baseball, lipstick case size cameras were placed under the second base bag, by ESPN, to give televiewers a dramatic perspective of the runner sliding into second base.

During the 1994 Winter Olympics in Lillehammer, Norway, the American Ice Hockey goalie wore a helmet camera to give the perspective of the game from the goalie's viewpoint. Since goalies tend to look where the action is, they can act as natural camera controllers. The wide angle lens gave a slight distortion in perspective, giving the appearance that the action is much closer to the goalie than it actually was. The most interesting action shots captured by the

goalie helmet camera were the ones just in front of the goalie. Unfortunately, the story that was told by this view point was not complimentary for the Americans. This is an example of how an improvement in the technology to capture a shot doesn't necessarily improve the story being told.

During the 1994 Olympics in Lillehammer, Norway, CBS also utilized cameras which moved along the sides of the bobsled and luge track and the speed skating rinks. The cameras travelled on tracks, alongside the athletes giving a close up on the profile of athletes as they skated along the track. Development on the track wall camera for speed skating began in 1988. According to Jim Allegro, Executive Vice President of ESPN, $600,000 was invested. Unfortunately it did not work in the beginning because they were not able to get the camera to accelerate quickly enough to catch the skaters as they skated along.

Capturing the action in speedskating was difficult because the camera had to accelerate to match the speed of the skater. The required camera action could be compared to that of runners in a relay race, where one runner has to run

fast enough to catch up with the other runner in order to complete the baton pass at full speed. Since the traveling cameras along the speedskating rinks are located on the straightaways, they must return to their starting position in preparation for the next lap. This particular traveling camera does a wonderful job at capturing the close-up human drama of the athlete. When traveling shots are used in combination with longer shots, televiewers can get a close-up on the action and they can understand how the close-up relates to the athlete's location and strategy. In bobsled and luge the cameras were located at the start of the track, making it easier to predict where and when the action would start.

The predecessor of the track camera was the 'sky-cam' which went into use in 1984. It was connected to two guide wires that were attached to the roof of a stadium. The camera moved at a speed of up to 40 miles per hour when the tension was increased or decreased at any of the four ends of the cables. The next moving camera innovation was the cable camera which ESPN introduced in 1992 for skiing events. The camera went straight down the hillside at speeds up to 40 miles per hour and shot a skier's profile for one

quarter of a mile down the course. Limited speed and the requirement for large amounts of reset time made the cable camera less reliable than had been expected [Rub94].

There is a dramatic difference between what can be captured by today's cameras and lenses and what was captured by the first cameras and lenses. It took twenty-five years[1] for the technology to be able to represent the action as it could be seen from the stands. Evolutions in camera lens technology have improved the ability to capture the human drama of sporting events through close up shots of the action, capturing the facial expressions of the athletes. Close-up shots alone can be very confusing, it is how they are imbedded into the rest of the story that they add meaning. One example of this would be taking two zoom lenses on opposite ends of a 50 yard line on a football field. If the viewpoint was switched from one camera to the next, the televiewer would be confused. The assumed point of reference would have moved without any visual clues. Even if the action captured by each camera was spectacular, it would still be confusing and would detract from the under-

1. Counting from the first televised sporting event in 1939.

standing of the storyline.[1] In football it is common to see the words 'Reverse Angle' on the screen, when the opposite viewpoint is presented, so the televiewer knows to adjust their frame of reference.

11.2   Graphics

Graphics are an important part of television today. They frame the stories and attract our attention to specific pieces of information which enhance our understanding of the story. A swirling box with a picture of a particular athlete draws our attention to the character in the box. We are told through the graphics that the athlete in the box is an important character in the storyline. Other relevant pieces of information are also introduced through graphics, like scores or statistics, which give the televiewer a frame of reference and a greater understanding of the significance of the action presented on the screen. If the score in a game is tied and there is a last minute attempt for a goal, the action is considered to be more exciting since it can effect the final

---

1. This is an example of breaking the 180 degree rule in film [Bor90].

outcome of the game. If the point spread between two teams in a game is large, the significance of one more point by the other team, in the final seconds of a game, is somewhat meaningless.

Graphics today can be quite elaborate and sophisticated. Networks spend thousands of dollars on good graphics for their programs, which capture the attention of the televiewers. Personal-computer-based graphics systems have been developed to place scores on the screen during television broadcasts of sporting events.

Graphics are very important to storytelling in sports. We are now accustomed to seeing elaborate graphics, but they have not always been very easy to produce. In the late 1950's, 40 foot vans were used to move the crew, cards, stands and cameras[1] to the games. The cards were preprinted with names titles and numbers which were used for scores and statistics. A camera would capture the image of small black cards with white letters. As a special effect, pull strips were

---

1. Information about the early days of graphics was provided by Clair Higgins [Hig94].

used to slowly uncover the letters on some cards. The supers[1] always looked washed out until the keying system was invented.

The key signal cut was developed in the early 1960's, which electronically cut out an area of the screen for graphics. Simple white letters and numbers appeared on a black background on the bottom half of the screen.

The first electronically generated graphics machines were actually developed in the middle of the 1970's. All the generated characters were the same size and the device memory was limited and slow. 'In sports the speed at which the information is presented is essential.' Clair Higgins recounted how they got around the speed and memory constraints by utilizing a telephone auto dialer device with magnetic strips. The auto dialer was programmed with the names of the players. When the name or information was selected through the alphabetized interface, the associated magnetic strip would be read into the graphics machine speeding up the process of creating graphics. This auto

---

1. **Supers** are the superimposed images.

dialer system was the first commercially available method for storing graphics information.

Today the number of human resources required for the creation of graphics have decreased due to the advances in digital technology. One black box, the 'Chyron Infinit!' which costs up to $120,000 fully loaded, only requires one operator. The 'Chyron Infinit!' is used by all major networks and most major market stations [Rub94].

Football games are enhanced by visual graphics which explain the strategy. The X's and O's used by John Madden, a well known football commentator, give the televiewers some insight into the plot of the game and highlights the significance of certain actions in the game.

At the 1994 Winter Olympics, a specific type of graphical annotation was used to help the audience understand the evaluation of figure skating jumps. Models were used to represent the terrain in downhill skiing. By allowing the televiewer to understand the difficulties in the sports, there is a greater appreciation for what is actually accomplished

by the athlete. Suspense is created when the televiewer knows they should be looking for specific points in the technical program, to see if the athlete is successful in their attempt. The dimension that is created by emphasizing the difficulties of an event or the strategy of the players gives the story more depth, and the televiewer a greater understanding.

11.3   Video Tape, Instant Replay & Slow Motion

The first unplanned video 'instant replay' took place quite by accident in July of 1963 during a New York Yankees baseball game, when the Director missed the action and quickly rewound the tape to show what was missed. (The game was not being taped for instant replay.) Though totally embarrassed, the Director was immediately heralded by his peers for his ingenuity, and the replay quickly became an integral part of televised sports [Barn82].

The idea of using instant replay became much more popular after it had been used to dramatize the story about the murder of Lee Harvey Oswald. A few weeks after the effective use of instant replay in telling the story about the Oswald murder, instant replay was used in the 1963, Army-Navy football Game, on New Year's Eve [Barn82]. Instant replay had a dramatic effect on the presentation of football on television. It no longer looked like jumbled figures on the screen. The crucial action could now be analyzed and re-

examined, and new meaning could be given to the events that occurred on the screen. Fans did not have to be experts to understand the game, since it was presented in a very understandable format. The Executive Producer for CBS Sports responsible for covering the Army Navy game was Bill Fitts, who recounted the experience during a telephone interview. 'The 1963 Army Navy game was the first planned video instant replay. Large trucks with tape decks were used to record the shots onto 2 inch tape. The objective was to cover Roger Staubach, the star quarterback for Navy. Wide shots focused on Staubach's options, while close ups were used to show his escapes from on-coming offenders. Unfortunately, Roger Staubach did not have a great game, but the Army quarterback had an exciting naked-reverse play which was dramatized through the instant replay.' Bill Fitts went on to say, 'the first official instant replay was done at the Kentucky Derby using film, which was developed quickly using the hot-can process, and shown during the last few minutes of the television sports program.'

Slow motion came much later, in the 1970's, and also played a significant role in storytelling for sports. Clair Hig-

gins discussed the first video technology for instant replay. 'Tape machines were modified which recorded at a faster speed. The tape was played back at normal speed which made the action appear to be simulated slomo[1].' Many film cameras have been manufactured with variable shutter speeds, allowing filmmakers to capture action at a different frame rates. If the capture rate, in frames per second, exceeds the projection rate the action will appear slow to the audience. Initially, TV sports casters simulated slow motion by shooting at the standard 30 frames per second rate and slowing down the playback. This technique results in a loss of perceived resolution. Today's variable playback with dynamic tracking machines improve the look by adding fields. More expensive and better quality cameras capture action at high frame rates specifically for slow motion.

The effect of the slow motion added to the televiewer's suspended state of disbelief pulling the televiewer into the story. The drama of the effect comes from the comparison of our perception during accidents or traumatic events in our lives. People will usually say that these types of events felt

---

1. **Slomo** is slow motion

as if they were happening in slow motion. The cognitive clock, during a traumatic event, allows us to process much more information from our senses at a much faster pace than one would at other times. The perception of time is different than the actual amount of time that has passed. [Cor93]. Representation of the experience to someone in a calm state would require more time to represent all the information that was processed during the heightened state of emotion. Slow-motion allows the televiewer to experience more details about what is going on without having to be in a heightened state of emotion. A video tape of a dangerous sport like bobsled or skeleton, from the point of view of an athlete, will always appear to be faster than the athlete remembers it to be. The athlete is busy calculating every move and is in a deep state of consciousness. This fear is not part of the viewing experience and cannot be easily recreated in games, because the televiewer lacks the risk that motivates the athlete.

We often see dramatic representation of certain events replayed in slow motion to highlight the significance of the event. Understanding what has transpired during a play or a

jump is critical to understanding of the story. Just seeing a figure skater fall at the end of the jump is not as meaningful as the slow motion, which presents the action at slow enough speed for the televiewer to see the figure skater's blade catching on the ice and causing her to loose her balance.

11.4 Color

The late 1960's brought color to sports television. The use of color became important. Team colors had meaning to the televiewer. Bright artificial turf became popular. Artistic Directors got involved and created fancy designs. The sports drama was becoming more human. Football players were becoming more dramatic and performed for the television audience. Dancing and spiking after a touchdown in football became popular. The athletes became more animated and their habits, like blowing bubbles and chewing tobacco, and spitting out the chewed tobacco, were covered on television [Mit76].

11.5 The Computer

Computer chips provide some control in high technology instrumentation, but the type of computer that helped tell a better sports story was first utilized in 1968 by ABC when covering the Summer Olympics in Mexico. Statistics and history enrich the sports story, but with so many competitors being covered at the Olympics, it would have been difficult to access all the statistics and information that pertained to the particular athlete and event. The ability to randomly access specific information allows the announcers to present an in-depth perspective to the televiewer or position the event [Rad84].

11.6 The Future

The television technologies that have evolved over the past 55 years have greatly improved television's ability to capture the human drama of sporting events.

The digital era will be another technological milestone improving the human drama of sports television. The ability

to tell the story in the way that most suits the televiewer is one example. A sophisticated televiewer could watch a sporting event with statistics and specific details about technological improvements in the sporting equipment, while an inexperienced televiewer can get general information which allows them to understand and, therefore, enjoy the event.

Merging actual events and video games becomes another possibility in the digital domain. Playing along with the golf professionals at the Masters' Tournament becomes possible through integration with a synthetic world, from where the home televiewer is able to participate in the event. Televiewers could actually become characters in the human drama of the sporting event they are watching.

12.0 Evolution of the Sports

Several sports were virtually developed solely for the purpose of appearing on television: Professional wrestling and roller derby in the 1950's, and professional beach volleyball and skiing in the 1980's. Golf and football modified their rules and scoring to work around the constraints of the television medium [Mit72].

Arena sports such as wrestling, boxing and roller derby were easy to capture in the early days of television when camera lenses were limited. Roller derby was specifically invented to provide the speed and violent elements the audience wanted in the story, within the restrictions of the available television technology [Rad84].

12.1 Golf

For centuries, golf was played in a format of match play, that is, one-on-one, hole-by-hole between competitors. Each hole was counted separately. A match was played until one

golfer had won more holes than their opponent could win in an eighteen hole match. Sometimes matches went for only ten holes, other times they did not end before the sun went down or the golfers retired due to exhaustion. Match play made it difficult for television, because the story could not be told efficiently within the allotted time window for the television event.

The medalist format, or the total score for 72 holes for each player, made it easier for television to capture the top golfers and the suspenseful action on the last holes where matches are won. By switching to the medalist format, television could capture the action of the event within a predicted amount of time. A captivating story could be told which kept the televiewer in suspense until the end [Mit72].

12.2   Football

Professional football has modified the timing rules of the game to change the length of time necessary to play a game so that a game will fit into a three hour television window. In addition, commercial time-outs have been built into each

game to allow the networks to air commercials without missing any action. The same 'TV Time-out' format has been implemented in college football, college basketball and NBA basketball [Hic92].

12.3 Baseball

Baseball was not captured well in the early days of television. Limited camera lens technology made it impossible to capture the human element of the sports. Since few cameras and no instant replays were used in the early days of television, the unpredictable action of stealing a base was difficult to capture. The unpredictable actions in baseball contribute excitement to the story [Mit76].

The evolution of television technology has made it easier to capture the action of the baseball events without having to change any of the rules. The ability to capture the human side of the event with zoom lenses, has made today's players more famous than their predecessors who were traded on baseball cards. Games now take over fifty percent longer and are highly commercialized.

12.4   Auto Racing

Auto racing is one of the most widely attended sports. Television has introduced innovative camera angles to capture the element of speed in this sport and attract the already existing numbers of fans to television viewing. Point-of-view cameras in the cars have improved the televiewer's perception of what the driver is facing as they try to pass another car. The suspenseful strategy of a pass and the attempt to block can be covered more effectively by the car mounted cameras. The view from the bumper is the most interesting because it gives the televiewer the sensation that they are hanging out on the edge of the car. The road appears inches below and the speed of the movement of the road gives the televiewer a true sensation of speed. Raceway Park in Indianapolis has agreed to bury a camera in the middle of the track so that ESPN televiewers can experience the speed at which the cars are moving from a very unique viewpoint [Rub94].

13.0 Improving the Story

The ability to convey a more realistic and intriguing story about sports has been enhanced by the availabilities of new media technologies. It took twenty-five years, from the time television technology was first used to cover sports in 1939, to be able to represent sports on television in a way which matched the view point from the stands. Today's television sports coverage is a tremendous improvement from what was available in the early decades of sports television. The experience is communicated much more effectively through current sports programming.

The enabling technologies evolved slowly, but through the use of these fundamental technologies, new techniques for storytelling in the area of sports were developed. One example is the use of instant replay to show critical plays from different viewpoints. Video tape technology had been available for years before it was determined that its use in sports programming could add a dramatic quality.

Future techniques which will take advantage of digital technology will be just as dramatic. History proves it won't be the technology alone that will create the dramatic changes in sports television, it will be the creative use of the digital technologies to tell the stories that will make the difference.

Section III Digital Technology for the Sports Fan

14.0   Overview

Section III focuses on the influence of digital technology on the future of sports entertainment, specifically the Synthetic Transition Shot, which is part of the research done in support of this thesis.

The Synthetic Transition Shot utilizes a three-dimensional model and prescribes an optimal path through the space represented by the model to create continuity. The intention is to create both continuity in sports which take place on a track and to create transitions between real footage and a synthetic environment in interactive video sports games.

15.0 What is Continuity?

Continuity can either make or break a story. In sporting events the visual continuity comes from the flow of the action. When multiple cameras are used to cover a sporting event, the composition of the successive shots must be inter-linked.

Track sports, e.g. bobsled, are continuous along the 'axis-of-action' which is the track. Cameras along the track capture the action as it passes. Cutting from one camera angle to the next can cause discontinuities if shots do not match at the transition.

15.1 Mechanisms for Continuity

There are four degrees of freedom with regard to the cameras: the number of cameras, the position of the cameras, the framing of the shot and the movement of the cameras. These camera parameters directly impact the composition

of successive shots, hence the visual continuity and the perception of speed and action.

David Bordwell discusses two forms of continuity editing in **Film Art an Introduction** [Bor90]. The first is 'narrative continuity' which describes the continuity in telling the story. In the example of a bobsled event the narrative continuity is carried by the action of the bobsled going down the track. The second is 'spatial continuity' which ensures common space from shot to shot by constraining the axis-of-action as captured by the camera. Crossing this axis causes spatial disorientation [Bor90]. Connecting segments are carefully planned around the axis-of-action. When a limited numbers of cameras are used to cover a bobsled track, planning around the axis-of-action is not possible. Spatial continuity is incumbent upon the number of camera and their positions.

There are several factors that affect the perception of continuity, some more important than others. When one visual cue is wrong, we look for other visual cues to understand the new environment in the scene. Camera movements,

color, texture, details in the background scenery, and relative speed of objects with respect to the camera motion all add to the perception of continuity of the visual space [Bor90].

Camera movement is another important component of continuity. It provides the window through which the story is told. Using a subjective camera movement creates a participatory effect [Mil90].

If the path of the camera is not smooth, it can be distracting. Cook discusses how camera movement has been used by film makers to create an effect. Shaking the camera, reminds the viewer of the camera's presence and can be a distraction. [Coo90].

15.2   A Sense of Space

'Camera movements can be seen as a convincing substitute for human movement and influence the viewer's perception of space.' Bordwell describes the drama created by different camera movements. 'Objects appear to be more solid and

three-dimensional when the camera arcs along a curved path around the objects' [Bor90].

Change in object size, as it moves relative to the camera, is another mechanism for the perception of motion. Towards either end of a tracking pan shot the object being tracked, e.g. the bobsled, appears to become smaller. Size constancy diminishes the value of the size cue for many objects, such as a receding bobsled, since there are few depth cues in a head-on projection of the bobsled.

15.3 Speed and Action

Background motion is the primary contributor to the perception of speed. Thus, the distance from the foreground object to the camera is important. When the camera is too close to the object being tracked, the background flow-field is occluded. This makes it difficult to detect the speed at which the object is traveling. When the camera is too far from the object, the background appears stationary as the object moves across the screen.
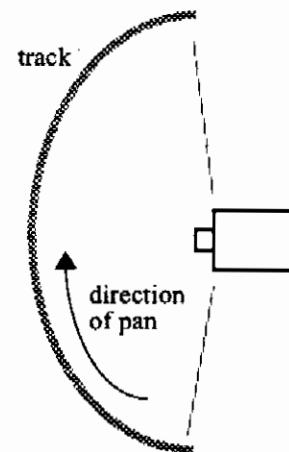

Figure 15.1: The distance between the camera and the action remains a constant size when the camera is located on the inside of the curve. The action moves around at the camera pans.

Due to the shape and slope of the curves in fast track sports, filming from the inside of the curve puts the action in the field-of-view of the camera for a greater period of time than is possible while shooting action in a straight-away [See Figure 15.1]

Increasing the number of cameras on the track increases the number of times that the action will be traveling perpendicular to the camera. This can result in an increase perception of speed [See Figures 15.2 and 15.3].
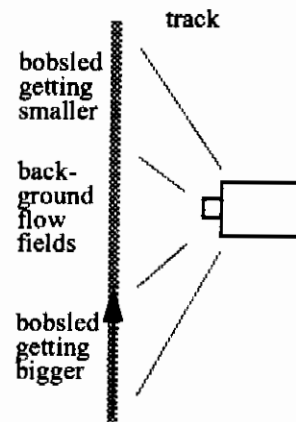
Figure 15.2: During the camera pan the camera appears to be going fastest when the action crosses straight in front of the camera. The bobsled changes size during the beginning and end of a long pan shot.
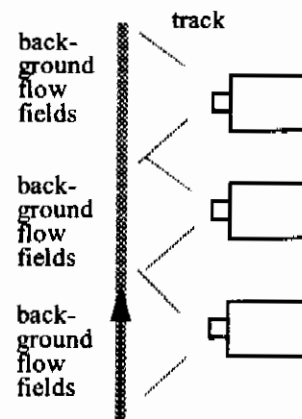
Figure 15.3: Greater numbers of cameras increase the perception of speed, since background flow-fields increase the perception of speed.

16.0   Capturing the Event

There are three shot types which typify track sport coverage: the point-of-view shot, the tracking pan, and the traveling shot. Each shot has differing characteristics regarding continuity and perception of speed. These shot types are discussed below in the context of a bobsled event.

16.1   The POV Shot

The point-of-view shot tells the story from the athlete's perspective. The motion of the track moving towards the camera gives a strong sensation of speed. In a bobsled POV shot, the camera only captures what is in front of the bobsled. The viewer can not see relative position on the track, e.g. the driver's lines.

16.2   The Pan

During a pan shot of a bobsled going through a straightaway, a large percentage of each shot is the bobsled either moving towards or away from the camera. When the bob-

sled is directly in front of the camera, the bobsled appears to be traveling faster than at any point during the pan shot Since the bobsled is in front of the camera for only a split second, the predominant contributing factor to the perception of speed comes from the changing size of the bobsled as it moves toward and away from the camera. Change in size is not as effective a mechanism for perceiving speed as change of flow fields in the background [Cor93].

16.3 The Traveling Shot

A traveling shot follows the action from a position perpendicular to the line-of-action. Traveling cameras have been constructed for speed skating, bobsled, luge and even skiing. Since the action of a vehicle remains directly in front of the camera during the shot the perception of speed is much greater [See Figure 16.1].
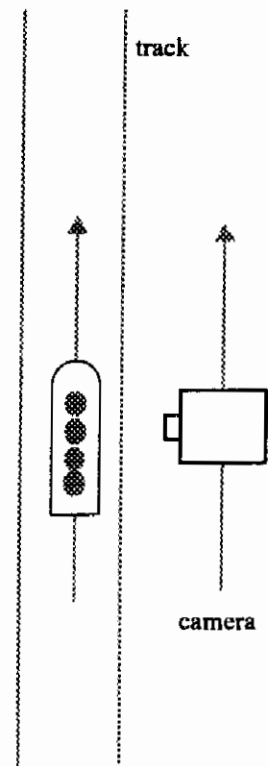
Figure 16.1: The Traveling Shot: The camera travels along with the bobsled. The flow field of the background gives the perception of speed. The bobsled remains stationary in the frame.

17.0   Telling the story

The way in which the shots are juxtaposed also impacts the story.

17.1   Rhythmic Jump Cuts

Spatial discontinuities can be introduced for effect and are commonly used in narrative film. Jim Allegro, Executive Vice President and Chief Financial Officer of ESPN, suggests that spatial discontinuities in bobsled and other track sports are desirable since they add to the perception of speed and suspense. If there are enough cameras along the side of the track, the cuts between cameras shots create a temporal rhythm. The footage of bobsled and luge at the 1994 Winter Olympics in Norway is an example of the temporal pace that can be created when large numbers of cameras are used to cover a track sport. This rhythmic alternative to continuity editing, works best when there are many cameras covering the length of the track to create a quick paced temporal continuity segment. At the 1994 Winter Olympics in Norway there were 22 cameras along the

mile long bobsled and luge track which created the effect of a faster tempo than created by the typical 6 cameras that are used to cover a bobsled or luge event [Rub94].

17.2 Match Cut on Action

Bordwell explains that a viewer's desire to follow the action across match cut is so strong that the viewer tends to ignore the cut [Bor90]. Our attention will be directed more towards the similarities than the differences between the two shots. A match cut only works when the 180 degree axis is not crossed between the cut from one camera to the next. Otherwise the frame of reference between shots is lost and the action is perceived to have switched directions.

17.3 Crossing the Axis-of-Action

Abrupt transitions between cameras which are on opposite sides of the 'axis-of-action' are typical of video coverage of

track sports. Jump cuts are made between a camera capturing the action moving from left-to-right within its field of view, and a camera capturing the action from right-to-left within its field of view [See Figure 17.1] Also each camera is looking at the a completely different background. The only element which provides continuity between the two cameras is the object being track.
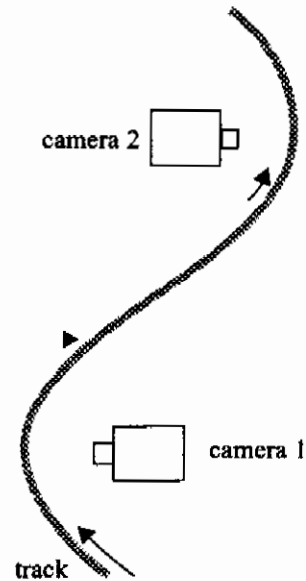
17.4   'Graphic Match' Edit

'Shapes, colors, tones of light or dark, or the direction or speed of movement from one shot are picked up in the following shot' to create transition from one scene into another. Graphic match editing is typical of classical narrative cinema [Bor90].

18.0   Current practice

There are three ways of creating continuity in track sports: The first is the single point-of-view camera. This is the easiest way since there is only one camera required, but it does not tell the whole story. Position on the track can not be detected through the point-of-view.

The second method requires many cameras which are evenly spaced along the track to create a temporal or rhythmic continuity. The progression of cuts from one camera to the next follows a beat. When there are a limited number of cameras along the track, must be strategically located at specific curves. Since the distance between cameras is long and uneven, it is difficult to create a rhythm.

The third method of continuity uses careful editing for visual continuity between shots when rhythmic continuity is not possible. Since the motion of a bobsled in a track is difficult to detect at great distances, visual continuity is difficult to achieve through editing when few cameras are used.

18.1 The Synthetic Camera

A fourth method, the Synthetic Transition Shot, creates continuity when few cameras are used to cover the action on the track. The goal of the Synthetic Transition Shot is to represent action which is difficult to capture with limited number of a traditional camera pans.

The Synthetic Transition Shot maintains spatial continuity, by creating a synthetic transition between two segments which are not spatially continuous. The transition moves the viewer through the space slowly enough for the viewer's frame of reference to be readjusted.

Unconstrained by the physical limitations of trying to move a real camera through the air, the camera in the Synthetic Transition Shot arcs around the moving bobsled giving viewers a greater sense of the movement of the bobsled along the track.

By creating a Synthetic Transition Shot which follows the direction of motion of the bobsled, the perception of speed is maintained as the bobsled slides down the track. Since the bobsled remains relatively stationary in the middle of the screen, the speed is perceived as the speed of the background moving past the screen.

19.0 Synthesizing Continuity

The Synthetic Transition Shot constructs continuity between abrupt transitions by synthesizing a traveling shot. Creating this synthetic shot requires a three-dimensional model of the environment and the ability to 'fly' the camera over the model.

Although interactivity could permit users to select the viewpoint of choice, it would take an experienced viewer to know how to position the camera to follow the action. The Synthetic Transition Shot constrains the camera to predetermined angles which best capture the action.

The Synthetic Transition Shot can create a seamless transition from real footage to a synthetic environment in a video game. The process of capturing the action is different for video games. Video games typically require the player to perform some action. The camera viewpoint must be linked to the player's actions.

19.1 Precedents of Spatial Continuity

Steven Yelick [Yel80] addresses the creation of continuity in the Movie Map Project by allowing users to change travel directions while taking a simulated drive through the town of Aspen, Colorado. Yelick synthesized a 360 degree pivot at the center of intersections by mapping four orthogonal views of the intersection onto the interior walls of a rectangular prism. The synthetic images are perspective projections from the center of the prism. [See Figures 19.1 and 19.2]
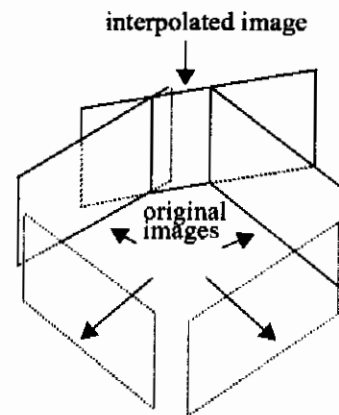
Figure 19.1: A cylindrical perspective can be simulated by projecting two angularly displaced views onto a plane [Yel80]

Figure 19.2: Yelick's resulting image[Yel80].

Also as part of the Movie Map Project a three-dimensional model of Aspen was created. This model included photographic textures projected onto the facades of landmark buildings in Aspen. The model supported unrestricted camera motion, but rather than using the synthetic footage for transition, it was used for juxtaposition with real footage, as a means of presenting an abstract representation [Bend80] [See Figure 19.3].

Figure 19.3: The image below is a three-dimensional model depicting the scene of Aspen, Colorodo shown above [Ben80].

Henry Holtman's [Hol91] particle database is another president for creating spatial continuity. By using simple rectangular primitives to model the kitchen from the **I Love Lucy** television show, a photorealistic three-dimensional particle database was created. Holtzman used this model to predict information occluded from the camera. These regions are lacking texture. In a follow-on project, Holtzman combined multiple frames from a camera moving through a space to "flesh out" the model. Holtzman's particle approach is attractive in that it provides photographic textures. Unfortunately, in the case of the Synthetic Transition Shot little of the model is in the field of view of either camera, hence the technique is not applicable [See Figure 19.4].

In all of the above examples, the camera is able to move through the scene but three-dimensional object motion is not supported.

All three approaches to creating continuity use video from the original scene to create texture and the dimension came from models built by hand.

19.2   The Synthetic Transition Shot

The key difference between the Synthetic Transition Shot and the research described above is that movement of the camera in the space is directly tied to the motion of the vehicle traveling through the space.

Due to the complexity of the bobsled track and the movement of the bobsled on the track, modeling from simple primitives was not possible. A graphical representation of the environment was constructed to represent the space which exists between the two discontinuous segments of real video.
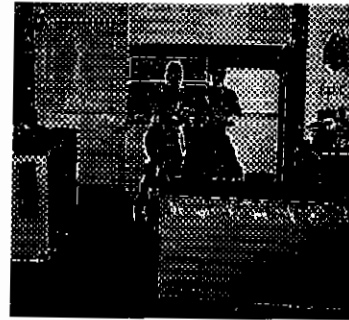
Figure 19.4: The image above shows Holtzman's three-dimensional database superimposed upon Lucy's kitchen. The image below was constructed using the database [Hol91].

The action from the real video footage had to be carried through into the Synthetic Transition Shot to maintain the momentum of the action into the synthetic environment. The action is the main narrative thread of the event and must be accurately represented.

19.3   Synthetic Match Cut On Action

The Synthetic Transition Shot creates continuity between two segments which are spatially discontinuous by constructing a segment which readjusts the viewers frame reference from one segment to another by inserting a simulated segment of footage between two discontinuous points. This must be done with sufficient accuracy to ensure that two discontinuities are not created, where previously there had only been one. Traditional film editing techniques are used to create continuity between the real footage and the synthetic footage.

Through the use of a 'match cut on action' between the real footage and the synthetic footage, the movement of the bob-

sled is carried across the edit between two shots, creating continuity.

The proper alignment of edit points between the video segments and the Synthetic Transition Shot is necessary but not sufficient to ensure continuity. The synthetic environment conveys to the viewer an impression that the background is the same, although there need not be the same amount of detail or resolution in the Synthetic Transition Shot as in the original footage.

'Graphic match' editing, as described by Bordwell, is also used in the Synthetic Transition Shot. 'Shapes, colors, tones, and the direction of movement' are all maintained between the real footage and the synthetic footage. The action remains in the center of the frame during the transition into and out of the synthetic footage [Bor90]. The use of a fade into and out of the synthetic footage emphasizes the graphic match of the elements in the real and synthetic segments.

20.0 Creating the Synthetic Transition Shot

20.1 The Track Model

Creating a Synthetic Transition Shot of a bobsled event required gathering enough information about the environment to build a three-dimensional model of the track. Multiple still shots from different angles were sufficient to gain enough information to manually build the model. Pictorial depth cues, linear perspective and vanishing points were used to extract the shape of the three dimensional environment as projected onto the two-dimensional surface.

It is important to know the focal-length of the camera which took the pictures, since focal-length determines the relative scale of foreground objects to the background.

Other information used in creating the model were actual measurements of the track and fence posts. The measurements insured that the proper linear perspective was used

[Cor93]. A map of the track provided the exact angles of the curves. When combined, this information resulted an accurate representation of the track.

Accuracy was critical when building the parts of the model which were close to the curves, where the transition from real footage to synthetic footage occurs.

Building a three-dimensional model on a computer is like creating a sculpture without being able to physically touch the model. There is a considerable level of complexity involved in finding the correct mathematical representation with which to adjust the model.

Figure 20.1: Proper linear perspective and exact measurements of the track were used in building the model. The spheres were temporarily used to insure the model matched the linear perspective of the track.

Figure 20.2: The model of the track had to match at the edit points between the Synthetic Transition Shot and the real footage.

Vanishing points, in combination with apriori knowledge of the physical size of the objects in the pictures, are extremely useful in recovering the focal-length of the camera [Cor93]. Since the dimensions of the bobsled track and the distance between fence posts alongside the track were known, it was possible to match the scale of the track to the scale of the fence posts in the images. This resolved ambiguities in the relative size of objects.

Figure 20.3: Vanishing points were used to line of the model with the pictures of the track.

Figure 20.4: Above is the modeled bobsled track.
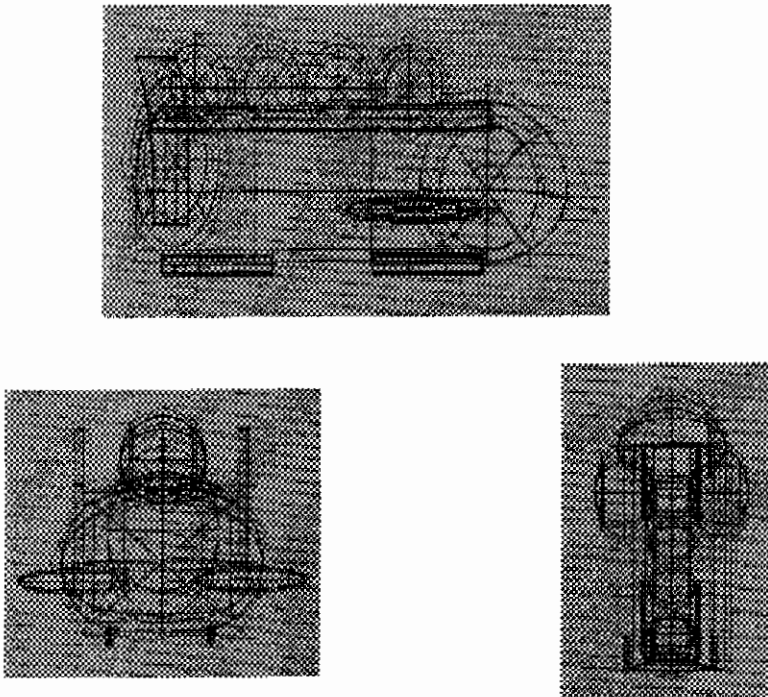
20.2 The Bobsled Model

Creating the model of a bobsled is much easier than creating a model of the track. The geometry of a bobsled is symmetric and simple. A simplistic bobsled was created to scale using actual pictures. The colors of the sled and helmets were matched to the colors in the real footage.

Figure 20.5 Side, front, and top views of the bobsled model.

Since, the focus of the viewer's attention is the movement of the bobsled from the actual footage into the synthetic transition shot and through the synthetic environment, the size and shape of the synthetic bobsled has to closely resemble the bobsled.

Also, the speed of the bobsled in the Synthetic Transition Shot had to be matched to either side of the jump cut in order to insure the momentum of the bobsled was uniform through out the shot.

21.0   Texture

While, the background details are not important to the storyline, the visual cues that a viewer derives by seeing the background move with respect to the action in the foreground are very important [Bor90].

The Bobsled remains in the center of the screen during the Synthetic Transition Shot, since the camera is traveling along with the bobsled. Gerald Millerson discusses the problem of the 'traveling shot': The effect of motion can be diminished when the camera is traveling with the subject. The viewer's perception of speed comes from the dynamic effect of the movement of the passing background [Mil92].

The first version of the Synthetic Transition Shot lacked texture in the background. The bobsled remained stationary in the center of the screen. The only perceived motion came from the movement of the track, which was textured. The bobsled and the background appeared to be stationary, while the track moved below the sled. This was disorienting for the viewers. Subsequent versions of the Synthetic Transition

Shot had a highly textured background which gave the illusion that the bobsled was traveling faster. The illusion was created by an increase in the flow field in the background.

The texture of the track selected for the final Synthetic Transition Shot is not an exact representation of the ice on a bobsled track. The low contrast texture and highly reflective surface of ice made it difficult to produce a flow field which both looked like ice and contributed to the perception of movement.

21.1 Lights and Shadows

Shadows contribute depth perception. Without any texture or shadows, the bobsled track appears to lack contour. Direct and indirect lighting, cast shadows on and applied surface color to the track. This made it easier to see the contour of the track.

To imitate the bluish color of light reflecting off snow in the real footage, the indirect ambient lighting value was set to give a bluish hue. A point source light, which imitated the

light from the sun was given a yellowish color to differenti-
ate it from the reflection from the snow. The position of the
point source light was matched with the position of the sun
in the real footage.

The reflectivity of the texture of the track effected the per-
ceived color of the track. When the track surface was mod-
eled with a Lambertian reflection, the diffuse reflection of
the lights on the matte surface enabled the viewers to see the
influence of the color of the lights [Fol93].

The track in the final Synthetic Transition Shot was created
with a slightly reflective surface to give the appearance of
ice. The reflectivity made it slightly more difficult to create
contour on the track through shading, than with the Lamber-
tian reflection.

21.2   Camera Movement

In the first version of the Synthetic Transition Shot there was an abrupt camera movement which was disorienting for viewers. The real footage had been taken with a stationary camera which panned as the bobsled traveled in front of the camera. The Synthetic Transition camera had to accelerate from the original stationary position to pass the bobsled and rotate around to the front of the bobsled. Once the camera was in front of the bobsled it traveled backwards to follow the motion of the bobsled. The only portion of the complex camera movement that caused disorientation was the quick acceleration, or jerk, in the beginning of the shot.

As Gerald Millerson's explains in his book, **The Technique of Television Production**, it is important that all camera moves are 'motivated, appropriate, smoothly controlled and at a suitable speed or it can be restless and disturbing for the viewer' [Mil90]. The objective of the Synthetic Camera is not to attract attention to the motion of the camera, but to highlight the motion of the bobsled as it moves through the space. When changes occurred slowly in the Synthetic Tran-

sition Shot the viewers commented that they were able to readjust their frame of reference and were able to follow the action presented by the camera.

Since the bobsled is moving at a constant acceleration, the camera must accelerate enough to catch up to the bobsled. It must then maintain the same speed until it is time to decelerate towards the transition back into the real footage.

The distance between the camera and the bobsled is also important, because it gives the visual cues to understand the action. If the camera is too close to the relatively stationary bobsled the background is occluded. This results in a diminished sense of motion. When the camera is too far away, the bobsled does not appear to be moving with respect to the vast background.

22.0   Conclusions

The Synthetic Transition Shot can be used effectively to create continuity between two discontinous segments, specifically for track sports, e.g. bobsled. The perception of the speed of the bobsled is not lost because of the use of a traveling shot. The movement of the textured background contributes to the perception of speed.

The 'match cut on action' combined with the 'graphic match' carried the viewer through the transition. The viewers' need to follow the action was so strong that minor differences in the model were barely noticed.

The fade between the synthetic and real footage helped enforce the graphic match since it appeared that the track, bobsled and background were all changing colors gradually.

Camera movement was one of the most important components of spatial continuity for the Synthetic Transition Shot. Camera movement was the one element which viewers were least forgiving of when there was a problem, and it had

the potential of making or breaking the perceived continuity of the shot.

Creating the model for the Synthetic Transition Shot was a complex task, but once a model has been completed it can be reused. Research currently being done at the MIT Media Laboratory by Shawn Becker and Ali Azarbayejani [Aza93] to automatically construct three dimensional models from images could be utilized to simplify the process of creating the model of the track.

23.0 Enhancing the Story

Special effects are used to illustrate a point and convey the illusion that something is happening which effects the storyline. The swirling graphics that are used to introduce a player in a football game, are not a true representation based on reality, but are an effect used to draw attention to the athlete in the box. They are an enhancement to the storyline and, therefore, do not detract from our viewing experience just because they are artificially created.

The use of the Synthetic Transition Shot for sports also enhances the storyline for sports which take place on a track. The unavoidable discontinuities that are natural in track sports can be minimized, giving viewers a smoother transition from one camera angle to the next.

Long straight-aways in track sports tend to be the most boring, since little change or danger exists on the straightaway. During the traditional camera pan, as the bobsled moves away from the camera into the straightaway, the bobsled appears to become smaller and the perception of speed

decreases. If the next camera pan along the track is on the opposite side of the track, the 180 degree rule will be broken, and there will very little visual continuity. By using the Synthetic Transition Shot, the perception of speed and continuity can be maintained.

23.1   Interactivity

Combining real sporting events with electronic video games could be accomplished through the use of the Synthetic Transition Shot. Track sports are not the only sports which can offer a simulated environment for viewers to compete on. One example, described earlier, would be mixing a simulated golf environment with an actual golf tournament in which professional golfers are playing. After actual footage of the professional golfer hitting his shot has finished, there could be a transition to the synthetic world where the home viewer can hit his or her shot using a special golf club with sensors. The home viewer's shot would then be calculated and ball placed on the course.

Acknowledgments

The Media Lab is a unique and wonderful place and I have really enjoyed being a part of it. I would like to thank all the people at the Media Lab who helped make the experience so wonderful and I would especially like to thank those who provided the environment which has made it possible for this research to be done, especially **Nicholas Negroponte** and **Andy Lippman**.

Walter Bender, thank you for being a wonderful advisor and for all the help, support, understanding, ideas, patience and endless proofreading that went into producing this thesis.

Glorianna Davenport, thank you for all the encouragement, insight, knowledge, ideas and for being a reader for my thesis.

Aaron Bobick, thank you for helping with the concept of the Synthetic Transition Shot and for being a reader for my thesis.

Mike Bove, thank you for your insight and sincerity.

Linda Peterson, thank you for being a good listener, proofreading my thesis and helping me maintain my sanity during the toughest of times. I really do appreciate all you've done.

References

Interviews

[Alc93]   **Fernando Alcala** is Vice-Presidente de
           Informacion Internacional, Televisa s.a. de
           c.v.

[All93]   **Jim Allegro** is Executive Vice President and
           Chief Financial Officer for ESPN.

[Fit94]   **Bill Fitts** was the CBS Executive Producer
           for the 1963 Army Navy football game
           which was the first planned video instant
           replay for a sporting event.

[Hig94]   **Clair Higgins** has been involved in sports
           television since 1948. He was part of the
           engineering crew for ABC and worked as a
           camera man covering sporting events. In
           1960 he started a company called Mobile
           Video Tapes, which was one of the first
           mobile television production facilities for
           sports. He also started Video Tape Enter-
           prises, which is based in Hollywood, Cali-
           fornia and specializes in sports production.

[Rub94]   **Harvey Rubin** is President of Sports Televi-
           sion Business Management, Inc.

Books

[All85]   Robert C. Allen and Douglas Gomery, **Film History Theory and Practice**, McGraw-Hill, Inc., 1985.

[Bar88]   Robert K. Barhart, **The Barnhart Dictionary of Etymology**, H. W. Wilson Company, 1988.

[Barn82]   Erik Barnouw, **Tube of Plenty, The Evolution of American Television**, Revised Edition, Oxford University Press, 1982.

[Bia92]   Shirley Biagi, **Media Impact An Introduction to Mass Media**, Second Edition, Wadsworth, Inc., 1992.

[Bis89]   Furman Bisher, **The Furman Bisher Collection**, Taylor Publishing Company, 1989.

[Bra70]   R. Brasch, **How Did Sports Begin? A Look at the Origins of Man at Play**, Van Rees Press, 1970.

[Bro82]   Les Brown, **Les Brown's Encyclopedia of Television**, New York Zoetrope, 1982.

[Bor90]   David Bordwell and Kristin Thompson, **Film Art**, McGraw Hill, 1990.

[Cla72]   Patrick Clark, **Sports Firsts**, 1992.

[Coo90]   David A. Cook, **A History of Narrative Film**, Second Edition, W. W. Norton & Co., 1990.

[Cor93]   Stanley Coren, Lawrence Ward and James
           Enns, **Sensation and Perception**, Version 3,
           Harcourt Brace College Publishers, 1993.

[Fis76]   A. Craig Fisher, **Psychology of Sport,
           Issues and Insights**, Mayfield Publishing
           Co., 1976.

[Fol92]   Foley, van Dam, Feiner and Hughes, **Com-
           puter Graphics Principles and Practice**,
           Second Edition, Addison-Wesley, Novem-
           ber 1992.

[Gif93]   Frank Gifford, **The Whole Ten Yards**, Ran-
           dom House, 1993.

[Goo90]   Michael L. Goodman, **Sports Illustrated
           for Kids Photo Finishes**, Time Inc., 1990.

[Gor94]   Jerry Gorman and Kirk Calhoun, **The Name
           of the Game, The Business of Sports**, John
           Wiley & Sons, Inc., 1994.

[Her89]   Mickey Herskowitz, **The Mickey Herskow-
           itz Collection**, Taylor Publishing Company,
           1989.

[Hic92]   Ralph Hickok, **The Encyclopidia of North
           American Sports History**, Facts on File,
           Inc., 1992.

[Hof89]   Dale Hofmann and Martin J. Greenberg,
           Sport$Biz, Leisure Press, 1989.

[Hor93]   B. K. P. Horn, **Robot Vision**, Ninth Printing,
           MIT Press, 1993.

[Hor89]   B. K. P. Horn, **Shape From Shading**, MIT
           Press, 1989.

[Ize89]   Jerry Izenberg, **The Jerry Izenberg Collection**, Taylor Publishing Company, 1989.

[Kie65]   John Kieran and Arthur Daley, **The Story of the Olympic Games 776 B. C. to 1964**, J. B. Lippincott Company, 1965.

[Kop81]   Leonard Koppett, **Sports Illusion, Sports Reality**, Houghton Mifflin Co., 1981.

[Lap86]   Richard E. Lapchick, **Fractured Focus, Sport as a Reflection of Society**, Lexington Books, 1986.

[McP89]   Barry D. McPherson, James E. Curtis and John W. Loy, **The Social Significance of Sport**, Human Kinetics Books, 1989.

[Men63]   Frank G. Menke, **The Encyclopidia of Sports**, Third Revised Edition, A. S. Barnes & Co., 1963.

[Mit91]   William J. Mitchell and Malcolm McCullough, **Digital Design Media, A Handbook for Architects and Design Professionals**, Van Nostrand Reinhold 1991.

[Mit76]   James A. Mitchener, **Sports in America**, Random House, 1976.

[ONe89]   Terry O'Neil, **The Game Behind The Game**, Harper & Row, 1989.

[Pop88]   Edwin Pope, **The Edwin Pope Collection**, Taylor Publishing Company, 1988.

[Pro68]   Vladamir Propp, **Morphology of the Folktale**, University of Texas Press, 1968.

[Rad84]   Benjamin G. Rader, **In Its Own Image, How Television Has Transformed Sports**, The Free Press, 1984.

[Sch93]   W. F. Schreiber, **Fundamentals of Electronic Imaging Systems Some Aspects of Image Processing**, Third Edition, Springer-Verlag, Germany 1993.

[Sim89]   J. A. Simpson and E. S. C. Weiner, **The Oxford English Dictionary**, Second Edition, Volumes V, XVI and XVII, Oxford University Press, 1989.

[Spa89]   Art Spander, **The Art Spander Collection**, Taylor Publishing Company, 1989.

[Ver88]   Bob Verdi, **The Bob Verdi Collection**, Taylor Publishing Company, 1988.

[Vog90]   Harold L. Vogel, **Entertainment Industry Economics**, Second Edition, CambridgeUniversity Press, 1990.

[Wat91]   John Watkinson, **The Art of Digital Video**, 1991.

Publications

[Ara94a]   Harvey Araton, "U.S. Squad Now Looks For Miracle", **New York Times**, February 22, 1994, Regarding the U. S. Hockey Team at the 1994 Olympics.

[Ara94b]   Harvey Araton, "In the Race of His Life, Koss Wins 3d Gold", **New York Times**, February 21, 1994.

[Ara94c]   Harvey Araton, "Sweet Taste of Redemption: Jansen Finally Wins a Gold", **New York Times**, February 19, 1994.

[Aza93]   Ali J. Azarbayejani, Bradley Horowitz and Alex Pentland. **Recursive Estimation of Structure and Motion Using Relative Orientation Constraints**. The IEEE Conference on Computer Vision and Pattern Recognition, New York, New York, June 1993.

[Aza94]   Ali J.Azarbayejani, Tinsley Gaylean, Bradley Horowitz and Alex Pentland, **Recursive Estimation for CAD Model Recovery 2nd CAD-Based Vision Workshop**, IEEE Computer Society Press, Los Alamitos, California, February 1994.

[Ben80]   Walter Bender, **Computer Animation Via Optical Video Disc**, Master's Thesis 1980.

[Ber90a]   James R. Bergen, Peter J. Burt, Rajesh Hin-
             gorani and Shmuel Peleg. **Computing Two
             Motions From Three Frames**, David Sar-
             noff Research Center Subsidiary of SRI
             International, Princeton, N. J., April 1990.

[Ber90b]   James R. Bergen and Rajesh Hingorani.
             **Hierarchial Motion-Based Frame Rate
             Conversion**, David Sarnoff Research Center,
             Princeton, N. J. April 1990.

[Bov89]   V. Michael Bove, Jr., **Synthetic Movies
             Derived from Multi-Dimensional Image
             Sensors**, PhD Dissertation, April 3, 1989.

[Bal91]   Anthony Balde, "Edifice Complex, As New
             Sports Stadiums Proliferate, So Do The
             Financial Risks. And Team Owners Are On
             The Hook", **Financial World**, November 6,
             1991.

[Ber94]   Ira Berkow, "A Prince Eschews Royal Digs
             While Seeking Olympic Crown", **The New
             York Times**, February, 20, 1994.

[Bre93]   Cathy Breitenbucher, "Speed Skating", **The
             Official CBS Olympic Viewer's Guide,
             1994 Olympic Winter Games Lilleham-
             mer**, 1994.

[Car94]   Bill Carter, "For Rivals of CBS, a Sweep to
             Forget", **New York Times**, March 7, 1994,
             pg. D4.

[Cra94]   Jack Craig, "Olympics on TV, CBS Crosses the Line", **The Boston Globe**, February 18, 1994, pg. 53.

[Chr89]   E. M. Christiansen, "1988 U. S. Gross Annual Wager", **Gaming and Wagering Business**, July 1989.

[Dia93]   Jeffrey A. Diamond and Michael Van Himbergen, "Media Fusion", **The Red Herring**, December 1993.

[Erl93]   Jonathan Erland and Nora Lee, "Specialty Venues, From Phantasmagoria to Outer Space for the Ride of Your Life", **The Red Herring**, December 1993.

[Fim91]   Ron Fimrite, "What If They Held A Sporting Event and Nobody Came?", **Sports Illustrated**, July 22, 1991, pgs. 49-52.

[Gui93]   Joe Guise, "Day by Day", **The Official CBS Olympic Viewer's Guide, 1994 Olympic Winter Games Lillehammer**, 1994.

[Hee89]   David J. Heeger and Eero P. Simoncelli, **Sequential Motion Analysis**, Vision Science, MIT Media Laboratory, AAAI Spring Symposium Series, Stamford University, March 1989. Focal Press, 1991.

[Hee90]   David J. Heeger and Allan Jepson, **Visual Perception of Three-Dimensional Motion**, MIT Media Laboratory, MIT, February 20, 1990.

[Hol91]   Henry Neil Holtzman, **Three-Dimensional Representation of Video Using Knowledge Based Estimation**, Master's Thesis, September 1991.

[Hor93]   Bradley Horowitz, Ali J. Azarbayejani, Tinsley Galyean, Alex Pentland, **Models from Video**, MIT Media Laboratory, Perceptual Computing Group Vision and Modeling Technical Report #207, 1993.

[Joh91]   William Oscar Johnson, "Sports In The Year 2001", **Sports Illustrated**, July 22, 1991, pgs. 40-48.

[Loe94]   Jim Loehr, "Jansen Had a Psychological Edge in His Skate to a Gold Medal", **New York Times**, February 20, 1994.

[Lon94a]   Jere Longman, "Torvill and Dean Can Only Rock to Beat of Bronze", **New York Times**, February 22, 1994.

[Lon94b]   Jere Longman, "Harding Receives a Break In Draw for Skating Lineup", **New York Times**, February 22, 1994.

[Lon94c]   Jere Longman, "It's Do or Die as U. S. Hockey Stares Down End of the Barrel", **New York Times**, February 21, 1994.

[Lon94d]   Jere Longman, "Just a Few Triple Axels And Suddenly Harding Is Seen in Golden Light", **New York Times**, February 21,1994.

[Lon94e]   Jere Longman, "For Torvill And Dean, A
             Rumba Into Lead", **New York Times**, Feb-
             ruary 21, 1994.

[Lon94f]   Jere Longman, "Blair Wins 4th Gold and
             Shows No Sign of Slowing", **New York
             Times**, February 20, 1994.

[Man94]   Michael J. Mandel and Mark Landler, "The
             Entertainment Economy", **Business Week**,
             March 14, 1994.

[Morg92]   Gretchen Morganson, "Where the Fans Still
             Come First", **Forbes**, April 27, 1992.

[Morr92]   Kathleen Morris, "The Gimmicks, With
             broadcast revenue due to fall teams scrounge
             for other revenue", **Financial World**, July 7,
             1992.

[McL91]   McLean, Patrick Campell, **Structured
             Video Coding**, Master's Thesis, MIT, June
             1991.

[Orw93]   Jon Orwant, **Doppelganger Goes To
             School: Machine Learning for User Mod-
             eling**, Master's Thesis, MIT, September
             1993.

[Oza92]   Michael K. Ozanian and Stephen Taub, "Big
             Leagues, Bad Business, It's Time to Restruc-
             ture Major League Baseball and Here's
             How", **Financial World**, July 7, 1992.

[Pen91]   Alex Pentland, "Photometric Motion", **IEEE Transactions on Pattern Analysis and Machine Inteligence**, Vol. 13 No. 9, September 1991.

[Pow93]   John Powers, "Figure Skating", **The Official CBS Olympic Viewer's Guide, 1994 Olympic Winter Games Lillehammer**, 1994.

[San94a]   Richard Sandomir, "Thirty Seconds Over Lillehammer on Air Tonya", **New York Times**, February 21, 1994.

[San94b]   Richard Sandomir, "Gumbel: Less Than Just a Pretty Face", **New York Times**, February 21, 1994.

[Smi93]   Mark Smith, "Satellite Delivered Sports, Where the Action Is", **Via Satellite**, September 1993, pgs. 42-48.

[Spr92]   Jim Spring, "Nine Ways to Play", **American Demographics**, May 1992.

[Sto94]   Bruce Stoff, "Skiing on TV: What's Wrong", **Snow Country**, January/February 1994, pgs. 58-64.

[Sny92]   Adam Snyder, "Baseball's Squeeze Play", **Cablevision Magazine**, April 6, 1992.

[Teo92]   Laura A. Teodosio, **Salient Stills**, Master's Thesis, June 1992.

[Vec94a]   George Vecsey, "Sports of The Times, Blair Holds Her Emotion For a Fifth", **New York Times**, February 22, 1994.

[Vec94a]   George Vecsey, "Sports of The Times, Com-
forting to Know Standards Still Exist", **New
York Times**, February 21, 1994. Skaters of
glory past can't fool the judges or Father
Time.

[Wil93]   Barry Wilner, "Bobsled & Luge", **The Offi-
cial CBS Olympic Viewer's Guide, 1994
Olympic Winter Games Lillehammer**,
1994.

[Yel80]   Steven Yelick, **Anamorphic Image Pro-
cessing**, Bachelor's Thesis at MIT.