Abstract. College sports generate revenue by selling media rights to media contractors. Media rights contractors generate revenue selling advertising boards at venues and selling ad slots to third party companies on platforms that live stream games. Advances in technology have enabled low (no) cost live streaming of sport events including those sports in the “long-tail” such as college soccer, tennis, gymnastics and high school games. Advances in technology have also enabled automated voice commentary and calculation of real-time complex game statistics. This paper describes the automation of live commentary of sports games with real-time complex game statistics to boost viewership to increase ad revenue. Game event data is input to the system. Game statistics are calculated and displayed to the audience as part of the stream. Play-by-play and color voice commentary are generated using pre-programmed scripts for each event in the game. Rule-based logic is used to decide which events to narrate, to capture the tempo of events in the game, to introduce variety in the narration, add real-time game statistics, and to introduce background facts about the players, the team, and the league. A business case analysis of live streaming “long-tail” college sports shows that adding voice commentary and live statistics to the live stream can increase advertising profit for a college such as George Mason University by $10,000 per sport, per year. This voice commentary service is 72% cheaper than the current commentary methods. In addition, a business case for marketing contractors shows that underserved sports at schools such as George Mason University can increase revenue by 84% per sport, per year.

Context Analysis

Media rights revenue for sports at colleges account for a significant portion of the total revenue for College Athletic Departments. For example, George Mason University’s Athletic Department receives $1,334,932 for full media rights, accounting for 6.6% of the Department’s total revenue ($20,184,400). More specifically George Mason Soccer accounts for 6.37% ($85,034) of GMU Athletic Department’s revenue.

A majority of Colleges in the United States contract their media rights with companies such as Learfield Communications LLC to increase revenue. In George Mason University Soccer’s case, the soccer program receives $85,034 for media rights, and Learfield generates $27,720 from the GMU streaming platform by charging for ad slots depending on audience size: $50 (0-100 in the audience), $100 (for 101-300 in the audience), and $150 (for >300 in the audience).
Currently, live streaming for long tail sports at colleges does not include commentary, limiting the entertainment factor that a soccer game. The lack of commentary exists due to the high costs of commentator salaries of at least $36,000/year ($18,000/year for a color and play by play commentator) (Sports Broadcaster, 2018). Adding live commentary to college soccer games adds entertainment, thus increasing viewership and ad revenue.

In addition, statistics collection for college soccer teams is limited and very basic, providing little to no information about a team or a player’s performance. Adding live, complex game statistics for players and team will increase recruits and soccer fans interest to watch a game, thus increasing viewership as well.

Advances in technology have allowed the automation of data collection. As mentioned earlier, an essential part of sports is the collection of statistics to assess team and player performance. The evolution of technology has facilitated the collection of statistics with accuracy. Data event providers use specialized artificially intelligent cameras, along with a dedicated, professional team, to record detailed information of 2000-3000 occurring events (actions performed by players) in a sports game. All these data events can be processed in an algorithm to calculate the desired team and player statistics. Moreover, event data collection can be used to automate live play by play commentary feed in text form, as provided in sports applications. This is an impossible feat for a human, as it is not in humans’ natural capabilities to process and analyze 2,000 entries of data (or more) simultaneously.

The evolution of technology has also improved the quality of voice synthesizers used in automated processes. Therefore, in the last years developers have been able to incorporate these artificial voices as part of their applications. Examples of this are Apple’s Siri, used to provide the iPhone owner with requested information; Amazon’s Alexa, used as an information tool that communicates with the user; Waze and Google Maps, used to give directions on the Global Positioning System (GPS).

**Stakeholder Analysis**

There are four primary stakeholders – College Athletic Departments, Commentators and Broadcasters, Audience, Data Event Providers, Advertisements Contractors – and three secondary stakeholders – Communications Commission, Leagues, and third-party companies – involved in the current college sports broadcasting system. College Athletic Departments have two main objectives: 1) Brand exposure, 2) Obtain valuable team and player statistics. Sports commentators and broadcasters have the objective of maximizing salary. The audience has the objective of watching quality sports commentary in their own native languages. Data event providers have the goal of providing quality statistics to College Athletic Departments while maximizing revenue. Media rights contractors aim to maximize ad revenue from college sports’ streaming platforms. The Communications Commission has the objective of accrediting broadcasting channels that pass qualification specifications, and Leagues have the same objective. Lastly, third party companies have the objective to increase revenue using ads during live streams. The most apparent tensions are present between College Athletic Departments and the Commentators, which relates to high salaries of at least $18,000/year per commentator.

**Problem Statement**

The absence of soccer commentary, due to high costs of $36,000/year, and complex game statistics at underserved colleges limits the ad revenues for media rights contractors.
Need Statement

Advances in technology have enabled increasing viewership in long tail sports in colleges. Modern technology allows the automation of processes such as the live collection of soccer game event data, used to provide live statistics, and voice synthesizers, used to replace human voices. There is a need to develop a system to provide low cost live soccer commentary and complex game statistics to increases live streaming viewership, thus increasing ad revenue for media rights contractors.

AUTOCOM System

Concept of Operations

The AUTOCOM system shall be capable of automating soccer commentary in multiple languages. The system is designed to also provide statistical insight by incorporating game statistical analysis in the narrations. The system will receive live event information from event data providers; furthermore, it will take this information and it will interpret it, analyze it, and convert it to play-by-play commentary using its text to speech feature. The system will be accessible through a graphical user interface and will be kept up to date by personnel working for sport broadcasting companies. External System Diagram (IDEF0), Figure 1, describes the interactions of the AUTOCOM system with external systems (Broadcasting Channels, Event Data Providers, and Weather Providers). In the IDEF0 there are four functions. The function modeling AUTOCOM is F.0 “Provide Automated Commentary and Statistics”. EF.2 simulates the game event Data Providers, EF.1 models the Broadcasting Companies, and EF.3 models the Weather Providers. The process begins when EF.1 is triggered by “Need to listen to live commentary”. At this stage, EF.1 outputs “User Request”, a trigger that initializes F.0. F.0 then initializes and immediately receives User Input from EF.1. F.0 confirms that it received this input by outputting an “Input Confirmation” message. After this, F.0 will parse weather information from EF.3 and receive Event Data from EF.2. F.0 will incorporate the obtained weather information to the initial game introduction. Throughout the rest of the game, F.0 will use Event Data to narrate the plays, make color commentaries, and calculate statistics. F.0 will constantly output game narrations and statistics until the Last Event Update, the last time EF.2 outputs an event update to F.0. At this stage, F.0 will output a game ending narration and a statistics end of half report. It is important to note that all the narrations outputted by F.0 trigger EF.1, and that the statistics outputted by F.0 work are considered inputs by EF.1. The implemented automated process closes the cost gap for college soccer commentary to not cost besides the annual operating costs from a seller’s perspective.
The prototype of this system must comply with the following mission requirements:

**Table # 1: Mission Requirements**

<table>
<thead>
<tr>
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<tbody>
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<td>The system shall provide play-by-play commentary with 99.0 % accuracy, given the accuracy of the data provided</td>
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<td>The system shall provide game statistics with 99.0 % accuracy, given the accuracy of the data provided</td>
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<tr>
<td>MR.2</td>
<td>The system shall provide live commentary in English and Spanish</td>
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</table>
The system shall incorporate ambient noise during a game (different events have different ambient noises)

**Design**

A functional description of the AUTOCOM process is described in Figure 2. This diagram depicts the automated process for soccer commentary, from the instance of receiving game event data, until the generation of voice commentary. The process starts with game event data being inputted into the AUTOCOM system. This data is then received and transformed into game events. Game events are sent to Event Identifier and Statistics. Event Identifier will classify each event as important, crucial, and non-important. Statistics will take the inputted data and convert it to statistics. Once the event is identified and the statistics calculated, both Event Identifier and Statistics will send its data to Data to Text section. Particularly, Statistics will also provide statistical information to Background Information. This will enable the system to have a historical background on statistics for a team’s performance. The artificial commentators can now statistically compare team performances during each game.

The text script is generated in the Data to Text section. As it can be seen, there are two different sub-processes inside this section: Play by Play Narration and Color Commentary Narration. Although they work the same, each sub-process has a different purpose. Play by Play Narration is in charge of developing the script for every play’s narration. This sub-process is generally called upon more than the Color Commentary process. On the other hand, the Color Commentary Narration process is responsible of developing the script for the color comments the broadcaster says. Both processes receive statistics from Event Analysis, and both processes incorporate statistics into their text script. For example, if the script is talking about a “Goal” event, the software could use statistical information to come up with come up with the narration. In this case, an example would be like: “Great goal by D.C. United! They have finally scored one goal after shooting 12 times!”.

As it can be seen, the software incorporated statistics in the narration by talking about the number of shots a team had before they scored their first goal.

It is important to distinguish that Color Commentary Narration and Play by Play Narration processes are not mutually exclusive, but that does not mean that they work together all the time. Because of the nature of the software, Color Commentary Narration will only occur with limited frequency in comparison with Play by Play Narration.

A distinct artificial voice will be triggered, depending on the text script that was generated. If the script was generated by the Play by Play Narration software, then the PBP Narrator Voice (play by play narrator voice) will be triggered. On the other hand, if the script was generated by the Color Commentary Narration, the CC Commentator Voice (Color Commentary Commentator Voice) will be triggered. Finally, whichever synthesizer is supposed to “speak” will do so and therefore output Game Narration.
**Figure 2: AUTOCOM Process**

**AUTOCOM Script: Decision Making Process**

Figure 3 shows a visual representation of AUTOCOM’s script decision making process. The decision-making process is represented by one iteration (while loop) and one global conditional statement (if statement): the decision iterates continuously while a soccer game is played and executes its conditional statements.

The first step the code executes after it transforms the received data to a list of game events is to iterate over this list of events. The system will proceed to identify and analyze each event and generate a play by play narration and color narration if necessary. By “identifying an event”, the code: a) understands what event is occurring, and b) classifies the event as “important”, “crucial”, or “not important”. The system calculates statistics in parallel with the event identification process.

Once the current event (event_i) is identified, the process to narration begins. The code finds the current event (event_i) in the list of important events. If event_i is in the list, it is therefore considered an “important event”. If not, it is not important. If event_i is important, then the code will generate a play by play narration text script and audio narration corresponding to that event. After narrating this important event, the code identifies if event_i is also crucial. The rationale behind identifying if an event is crucial or not is to generate color commentary. Color commentary should only be done with events that are important in a soccer game. If event_i is crucial, and the following event (event_i+1) is not crucial the software will generate a color commentary with a probability of 40%—meaning that it will generate a color commentary 40% of the times the code reaches this decision. It is important to consider the following event (event_i+1), because a human commentator would not give a color commentary on an event if the immediate next event is also very important. For example, a commentator would not give a comment on a shot if the next event is a goal.

If the event_i is not important, then the code will analyze the current game time. If the current game time is at a 15-minute increment, then there will be a Performance Assessment Commentary, where narrators give a comment on the statistical summary of the game. If the game time is not at a 15-minute increment, then the process will proceed with the next iteration.
Every event is stored into a database; therefore, every event has an “event number” (i). At this instance in the code, if the event is not important and game time is not at 15-minute increments, the software will analyze if the event number (i) is divisible by 8; the code will narrate every 8 events in case of the absence of important events, or if the game time is not a multiple of 15 minutes. If (i) is divisible by 8 then the system will execute a play by play narration. If event_i is equal to “Corner Cross”, “Corner Pass”, or “Pass”, the software will output color commentary with a probability of 40%.

If the previous conditions are false, then the code will evaluate the position of the ball in the game. If the ball is in the middle of the field (neutral zone) -- from the x-coordinates -27 to 27-- and the game time is divisible by 16 seconds, the system will output a background color commentary with a probability of 15%. A background color commentary is when the narrators provide information pertaining the teams that are playing, but not necessarily about the game itself. An example could be when commentators talk about the stadium, specific players, transfer rumors, among others.

Finally, if the previous conditions are false, the software will skip event_i and continue narrating the following event. Regardless of what the output narration is, the software will always narrate the game if the game is on. If the game is stopped for any reason (half time, game suspended, game is over, etc), the software will receive no additional game event feed, thus stalling narrations. However, to keep the audience entertained, the software provides the audience with entertaining music.

![Figure 3: Script Decision Making Process](image)

**Test Results**

The results of this project can be observed in the project prototype. The prototype was tested with seven games for 90 minutes, and seven teams, the teams being: D.C. United, New England Revolution, Toronto F.C., Columbus Crew, Real Salt Lake, Philadelphia Union, and Montreal Impact. The prototype can output play by play and color narrations, calculate statistics for teams and player that are mentioned, and give a description of the current weather at the game’s location, among other functionalities as shown in figure 4, figure 5, and figure 6. The prototype is programmed to satisfy mission requirements, shown in Table #2, in two languages, English and Spanish. Each mission requirement was tested seven times. After initial testing, it was concluded that the system would have an optimal performance when allowing a delay of over 30 seconds from the real time of the actions being performed, thus allowing the software to retrieve a list of event data and decide on the narrations that will be provided in the future. The team added ambient music.
sounds to the software’s narration to compensate for the artificial voice’s lack of emotions. It is important to mention that the testing environment is controlled such that the data feed is not received live but simulated (as if it was being received live), and that the team did not develop an API retrieval component, but rather a component that retrieve data from CSV files. Lastly, it is important to note that the team is testing for voice commentary, and that an audio/video synchronization tool was not developed. Given the controlled environment, the software has passed the mission requirements.

Figure #4: System sample narration output

Daniel Johnson: DC United passing the ball beautifully.
Daniel Johnson: On the move and able to cut the pass.
Daniel Johnson: Kelin Rowe takes New England Revolution throw in.
Daniel Johnson: Timely tackle!
Daniel Johnson: Andrew Farrell has possession of the ball.
Daniel Johnson: Andrew Farrell liking to have the ball at his feet.
Alex Smith: Gillette Stadium can hold up to 10000 fans. I am sure engineers designed the stadium contemplating that all of them will be actively jumping and cheering for their team. After all, the crowd is the considered to be 12th player, so just like the rest of the team, they should be giving all their efforts to help the team win.
Daniel Johnson: Jose Goncalves has possession of the ball.
Daniel Johnson: Bill Hamid passes the ball.
Daniel Johnson: DC United passing the ball beautifully.
Daniel Johnson: Chris Tierney liking to have the ball at his feet.
Daniel Johnson: Brad Knighton sends the ball to space as he clears the ball out of danger.
Daniel Johnson: Taylor Kemp trying to make the ball circulate.
Daniel Johnson: That is a cheap way to lose the ball.
Daniel Johnson: Good block by Lee Nguyen!

Figure #5: General Team Statistics sample output (also calculated for every player on the field)
Table # 2: Mission Requirements Evaluations

<table>
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<tr>
<td>MR.1.3</td>
<td>The system shall provide game statistics with 99.0% accuracy, given the accuracy of the data provided</td>
<td>Statistics are 99% accurate.</td>
</tr>
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</tr>
</tbody>
</table>

Business Plan for AUTOCOM

AUTOCOM’s primary customers are media rights contractors. There are 1941 Athletic Departments that offer soccer programs in the United States. AUTOCOM expects to have a market penetration rate of seven percent, increasing exponentially as the company becomes prominent in the market. The company expects to capture 50% of the market (970 Athletic Departments that offer soccer programs) in five years.

AUTOCOM’s cost breakdown is decomposed into:

a) Startup Costs of $115,500:
   - Code Efficiency Work (1 week) – 1 Developer: $2,200
Voice and Video Synchronization (2 people: 4 months): $75,000
- Patent Claim + Patent Maintenance Fee: $20,000
- Initial Startup Legal Costs: $5,000
- API Component Development – Back End (2 weeks, 1 Developer): $4,400
- App Development – Front End (4 Weeks, 1 Developer): $8,800

b) Fixed Costs of $543,300:
- 5 Systems and Software Engineering Salaries: $425,000
- Premium Health Insurance: $25,000
- Contracts (Accounting Services): $42,000
- Contracts (Legal Services): $500
- General Liability Insurance: $1000
- Office Space Insurance: $500
- Office Space utility $300
- Office Rent: $24,000
- Unexpected System Failures Maintenance Contract + Website Support Contract: $25,000

c) Variable Costs: Customers at year i * $5,000(cost to support a customer)

Accounting for the mentioned expenses, AUTOCOM expects to license its product at a price of $10,000, thus generating $23,453,315 in revenues and $9,127,002 in profits after five years of sales, meaning a return on investment of 7.144%.

Business Case for Learfield Communications Inc.

As stated in the AUTOCOM business plan, each license costs $10,000/year per school. Analysis has forecast the streaming audience to double with commentary and live statistics updates added to the live streaming video. An increased game by game viewership allows Learfield to increase the ad slots fee for high audience games (>300 in the audience) to $250/game per slot. This results into an increase from $27,720 to $51,030 (84% increase), or an additional profit of $13,310.

Conclusion and Recommendations

Based on the preliminary results, automating game narration is possible using current technology and can be used as an alternative to current play-by-play sports commentary methodologies. For the system to work in a real-time, unsupervised environment, additional software development work must be completed: developing an API game event retrieval component and an audio/video synchronization component. After these enhancements are in place, operational pilot testing must be conducted with a customer, such as George Mason University, to ensure and refine functionality of the system.

As noted in Learfield Communications’ business case, the company can increase revenue from $27,720 to $51,030 (84% increase), or a profit of $13,310. George Mason University benefit from the AUTOCOM platform by increasing brand exposure due to an online soccer audience that is expected to double. Similar results could be expected for other collegiate sports such as basketball, football, etc., however, the AUTOCOM Team will focus on application to soccer initially.

If the AUTOCOM Team can prove out the profitability of this venture at George Mason University, it is highly likely that this success could be replicated at other universities, resulting in a very large potential market valuation in the next 2-3 years. Expanding into other collegiate sports will require additional investment but will also increase the potential revenue and profitability of the new play-by-play sports commentary solution.
Acknowledgment

Dr. Lance Sherry of the Center for Air Transportation Systems Research and Dr. Darren McKnight of Integrity Application Inc.
References

Biography

The authors are all senior Systems Engineering majors at George Mason University and will be graduating in Spring 2018. Jad Beydoun was born and raised in Lebanon and started in the program in 2014. Daniel Gutierrez is an international student who was born and raised in Costa Rica; he is part of George Mason University’s Men’s Tennis team, and he also joined the program in 2014. Majid Zarkesh transferred to George Mason on 2015, after spending his Freshman year in Virginia Commonwealth University (VCU). Salman Barzanji is also an international student that entered the program in 2014; he was born and raised in Saudi Arabia. Mohammed Haque was born in Bangladesh, but eventually came to the United States in 2008; he also started in the program in 2014.