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Most Effective Pitches Against Ronald Acuña Jr.

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Abstract

This document presents a quantitative study on the most effective types of pitches against Ronald Acuña Jr., a prominent baseball player, during the year 2020. Through an exhaustive methodology that includes data collection and analysis on pitch types, game conditions, and location, the project seeks to offer pitchers an analytical tool to improve their in-game decisions. Using the open-source platform Silver Decisions, a decision tree analysis allows the study identify patterns and trends in Acuña's at-bat behavior, offering specific strategies to deal with him in the most effective manner.

Keywords
Baseball, Effectiveness, Statistical Analysis and Pitching Strategy.

1. Introduction
Ronald Acuña Jr. is a baseball player born in La Guaira, Venezuela. After a whole life of following his father and grandfather dream, he made his debut in the Major League Baseball (MLB) in the year 2018, where he became an idol for his country. In the year 2023, he emerged as one of the players who most frequently approached the batting zone for his team, the Atlanta Braves, as well as one of the most effective, thanks to his strength and running style he led the team in total runs, hits, and total bases made. As a result, he became a constant threat to all pitchers in the league. However, like any human, there were occasions when his batting fell short, providing the opposing team with an opportunity to get back in the game.

The primary focus of this study is to deeply understand how Acuña interacts with several types of pitches during games and verify the impact of these interactions on his overall performance. Specifically, our goal is to analyze the percentage of times Acuña successfully connects with each type of throw and the number of bases he advances after these contacts. This meticulous analysis is crucial to fully understand the skills and preferences of an elite batter, enabling a deeper understanding of his strengths and weaknesses on the field. This, in turn, facilitates the development of a training plan for pitchers to maximize their ability to challenge the batter.

The methodology employed in this project is comprehensive, combining the collection of various statistics such as pitch types, game conditions, location in the strike zone, and batting outcomes. This approach goes beyond raw results, allowing a deep knowledge of the game settings, which provide the most complete picture of Acuña's performance. It is worth noting that the study took several considerations into account to generate the analysis, each of which is explained further and all of which contributed the software's capacity to process the information. Silver Decisions was selected as the main analysis tool due to its accessibility and simplicity, unfortunately, this caused problems to examinate properly the big amount of data getting through.

1.1 Objectives

- Analyze Ronald Acuña Jr.'s Performance: Understand how Acuña interacts with distinct types of pitches during games and evaluate the impact of these interactions on his overall performance.
- Identify Effective Pitching Strategies: Determine the most effective types of pitches against Acuña by analyzing his ability to connect with the ball and the outcome of these connections.
- Provide Analytical Tools for Pitchers: Offer pitchers advanced analytical tools to make informed decisions about pitch selection in various game contexts.
- Enhance Baseball Strategy and Knowledge: Contribute to the broader knowledge of baseball dynamics and tactics through a quantitative analysis of pitching strategies against a high-caliber batter like Acuña.

2. Literature Review

Baseball is a sport that is played between two teams of nine players each, with the objective being to score runs by hitting a ball with a bat and running around a series of four bases arranged in a diamond shape. The game is divided into innings, with each team taking turns to bat and field. The team that is batting sends one of its players, known as the batter, to the plate, where they face the opposing team's pitcher (Bonsor et al., 2023). The pitcher throws the ball towards the batter, who attempts to hit it with the bat. If the batter successfully hits the ball, they must run to first base, then to second, third, and finally home plate, to score a run. Meanwhile, the fielding team tries to get the batter out by catching the ball before it hits the ground, or by throwing it to one of their teammates who is standing on one of the bases that the batter is trying to reach (Bonsor et al., 2023).

Baseball is a game of strategy and skill, with many different aspects to consider, such as pitching, hitting, fielding, and base running. In this study we are focusing on the pitcher's decisions. Pitching in baseball is the act of throwing a baseball towards home plate with the goal of getting the batter out. Pitching is one of the most critical aspects of the game, as it is the primary means by which the defense attempts to prevent the offense from scoring runs. There are several different types of pitches that a pitcher can throw, each with its own unique characteristics and intended outcomes.

At the major league level, pitching is a game of strategy and deception. It's not just about how fast you can throw or how much your pitches move; it's about keeping the hitters guessing. That's why coaches and players go to great lengths to keep their signals secret and try to steal signs from the other team. The information about pitch selection is incredibly valuable because it can give a team an edge (Woodwart, 2023).

For this very reason there are studies in various areas, in relation to decision trees and predictions there is a study made by Noah Woodward published in the Hardball Times that approaches the same matter with a different perspective, in said study they intend to predict the pitch so the batter can respond accordingly, this study differs in that we are predicting the batters response to different pitches and choosing accordingly so that the pitcher can decide appropriately.

We decided to use a model to do our pattern recognition for us. The model needs to be flexible so that we can include many different pieces of information, and it should use the most important factors we provide to make predictions. We chose to use a decision tree for this task because decision trees are great at taking a lot of data and picking up on trends.

A decision tree is a graphical representation of a decision-making process. It is a tree-like model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. It is one way to display an algorithm that only contains conditional control statements. The decision tree structure is a set of nodes where each node is either a decision node (which has two or more branches), a chance node (which has two or more branches) or a leaf node (terminal node) that assigns a classification or a value.

The topmost decision node in a decision tree is known as the root node. It represents the best predictor variable. The branches represent the decision rules, and the leaf nodes represent the outcomes. The paths from the root to the leaf represent classification rules.

3. Methods

The first thing to do was a breakdown of every aspect that a pitcher must consider before the throw, consequently, the decision tree analysis starts from the moment the player gets ready to launch the ball, which is when he must consider several situations such as:

- **Game context:** the current situation of the match that may include total outs, other runners on the field, match score and the inning of the game. With research and analysis purposes, the game conditions were simplified to whether there are players on the field, and on which bases they are located.
- **Hitter evaluation:** strengths, weaknesses and historical tendencies of the batter are contemplated A statistical exploration of the different types of balls that have been faced before and how well does the player has reacted.
- **Pitch selection:** based on the hitter evaluation and the game context, the pitcher chooses one of the already existing pitches. This is usually based on the player's experience and judgement.
- **Speed and location:** the pitcher now decides where to place the pitch, inside or outside the strike zone, and how fast the ball will go
- **Physic and mental condition:** the pitcher's physical state, level of fatigue, and mental condition at that specific moment must be consider, even though all the players get ready at training, their body still gets tired during the game, also, they could lose the concentration at any time.
- **Long run strategies:** Review how does every pitch aligns to the overall strategy for the hitter and the game. For this decision tree, the long-term strategy was simplified to only include the number of players completing their run.

The decision tree of a pitcher is too complex to deeply show the strategy of a full game, this is caused by the fact that many of these situations cannot be easily measure or there is not enough data to make a correct analysis, such as the in-game physical and mental condition, furthermore, the complexity of incorporating on a decision tree the long-term strategy of the match drastically increases with every single variable. In consequence, the decision tree was made as simple as possible, and only includes as variables the game context, the hitter evaluation and a simplify long run strategy to select the most effective pitch.

Once the decision variables were selected, the next step was to build the diagram, we sought for the simplest form of the game, where the pitcher throws the ball and the hitter either hits it or not. If the batter connects, we consider how many bases are run in total, we supposed that the runners always cover as many bases as the hitter. Taking all this into consideration, the decision tree started with an equal chance node, which determines the current state of the game in terms of how many runners are currently on the field and in which base they are. This section has 8 different possibilities, each with a different key in the decision tree, this are shown below:

- No players on any base
- One player on base 1
- One player on base 2
- One player on base 3
- Two players on the field, one on base 1 and another on base 2
- Two players on the field, one on base 1 and another on base 3
- Two players on the field, one on base 2 and another on base 3
- Three players on the field, one on each base

Next, a decision node appears to allow the pitcher to select the type of pitch, of course, the decision is made based on the game context already analyzed. In total, the pitcher has 9 different types of throws, however, Acuña did not record data for 2 of them, the Slow Curve (CS) and the Knuckleball (KN), so it was decided to omit them. The other types of pitches that were added to the decision tree are:

- Fourseam (FA)
- Slider (SL)

- Sinker (SI)
- Changeup (CH)
- Curveball (CU)
- Cutter (FC)
- Splitter (FS)

Each option has a specific probability of the batter, in this case Ronald Acuña, to either connect or fail the swing. Additionally, to simplify the data analysis, a failure includes to miss the hit, instances where the ball were caught before touching the field (Flyout), as well as fouls and invalid hits. Following these criteria, player statistics are inputted, and if the hitter contacts the ball, the number of bases covered by the hitter was determined in one of 4 categories:

- 1 base
- 2 bases
- 3 bases
- Home Run

4. Data Collection

The official MLB database was used for the initial approach to Acuña's statistics, obtaining general data from his regular season. We highlight the total number of At Bat (AB) appearances, as well as his total hits (H), and the total occasions he managed to achieve a Single, Double, Triple, or Home Run after a hit. All these values were crucial for the further data analysis; however, for the decision tree to function correctly, detailed information for each of his hits was necessary. We found these detailed statistics on Baseball Savant, a website referenced by the league's official page, which retrieves and stores comprehensive information for all MLB players. Here, we found specific information about the types of pitches Ronald Acuña had faced during his regular season, as well as data on velocity, power, pitch location, among others. The retrieved information is presented in Table 1.

Table 1. Ronald Acuña's statistics in 2023 regular season, showing each one of the selected pitches, the amount of successful hits and their results (1, 2, 3 or 4 bases traveled).

Pitch Type	Singles	Double	Triples	Home Runs	Total
Fourseam (FA)	27	11	0	13	51
Slider (SL)	27	13	1	11	52
Sinker (SI)	44	4	1	8	57
Changeup (CH)	13	2	1	1	17
Curveball (CU)	9	2	1	4	16
Cutter (FC)	13	2	0	2	17
Splitter (FS)	2	0	0	2	4
Total	135	34	4	41	214

5. Results and discussion

5.1 Numerical Results

With all the considerations already described and after collecting data from his 2022-2023 season, a probability table (see Table 2) was generated in which we found the probability of connecting with each type of ball, with the probability of failure being the complement (1-p), and likewise the number of times connecting led to you gaining n number of bases. It is worth noting that our base stealing probability corresponds to the player's own results, so these will vary between each subject analyzed.

Table 2. Ronald Acuña's probabilities of getting bases according to the type of pitch.

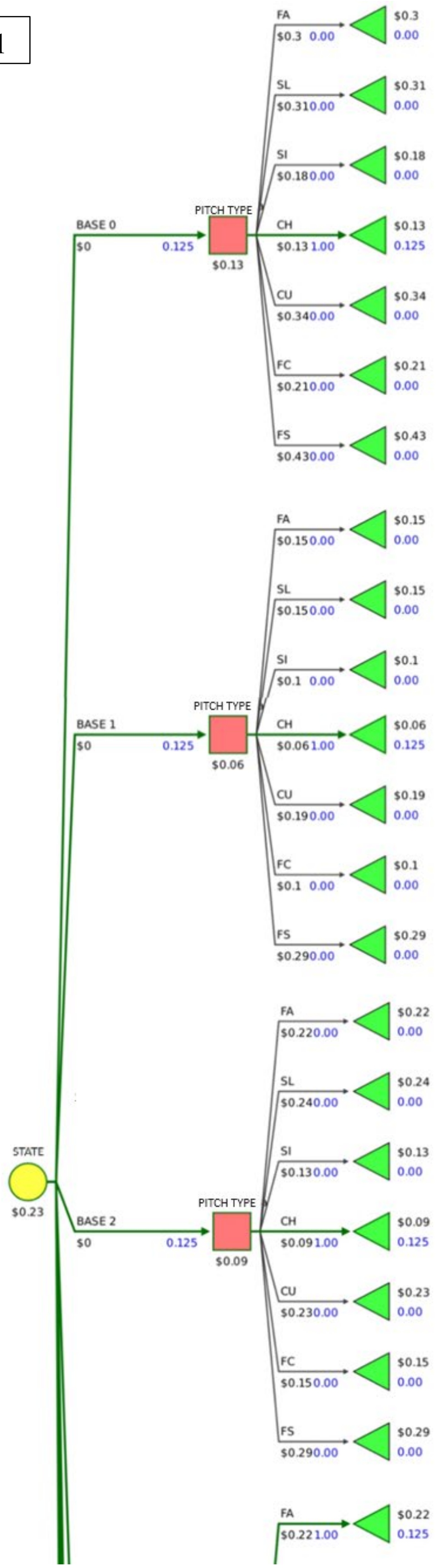
Pitch Type	Probability of connecting	Probability 1B	Probability 2B	Probability 3B	Probability HR
Fourseam (FA)	0.3018	0.5294	0.2157	0.0000	0.2549
Slider (SL)	0.3399	0.5192	0.2500	0.0192	0.2115
Sinker (SI)	0.3497	0.7719	0.0702	0.0175	0.1404
Changeup (CH)	0.3148	0.7647	0.1176	0.0588	0.0588
Curveball (CU)	0.3404	0.5625	0.1250	0.0625	0.2500
Cutter (FC)	0.4359	0.7647	0.1176	0.0000	0.1176
Splitter (FS)	0.2847	0.5000	0.0000	0.0000	0.5000

Finally, to give it a long-term projection, the number of players who completed the run depending on the initial game context was added. For example, let's imagine a play where the batter connects with the ball and runs 1 base. In a context where there is a player on first base, nothing significant happens to the game, even though on the next play there will be 2 players in play. However, in a context where there is a player on third base, this base that the batter just won becomes a run for the team. It is in this way that a different value was assigned to each number of bases traveled according to the initial context. Finally, we must configure the decision tree to seek to reduce the total number of runs made by the opposing team, in other words, to provide a minimization function.

5.2 Graphical Results

For processing purposes and ease of software management, it was necessary to split the decision tree into two parts, because of attempting to include all possibilities in a single model proved more challenging than expected, the Silver Decisions program couldn't process that amount of data. The first part of the analysis includes everything related to the initial 4 scenarios a pitcher could find: no players on the field and if there is 1 player, specify their base. On the other hand, the next part of the tree handled values related to combinations of players that can be on the field (Base 1-2, Base 1-3, Base 2-3, and Base 1-2-3). Finally, a third decision tree was generated (Figure 1), which synthesizes the results from the other two using the expected payoffs already calculated by the software, this final decision tree shows the values for all 8 scenarios the pitcher may encounter.

1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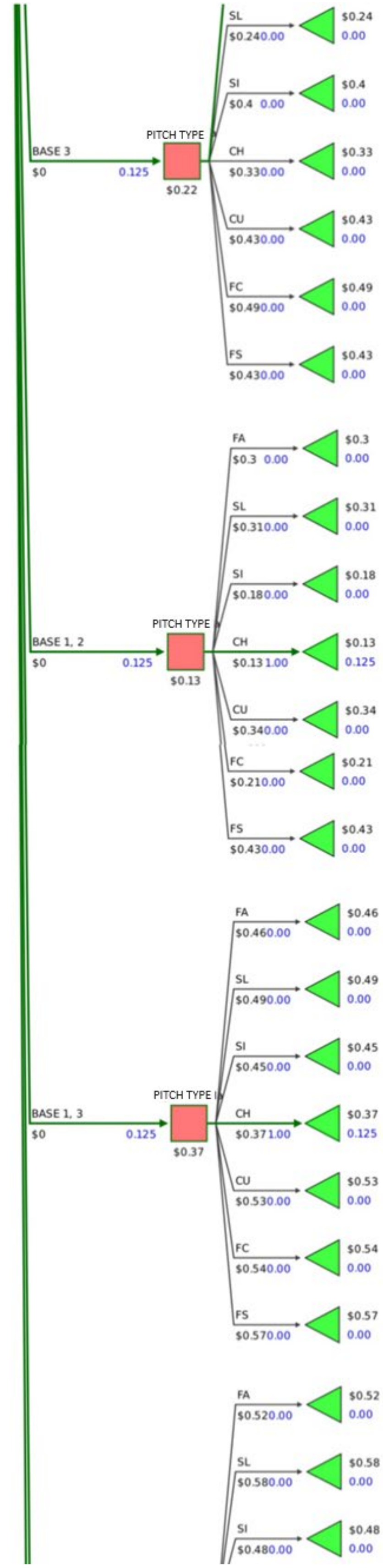
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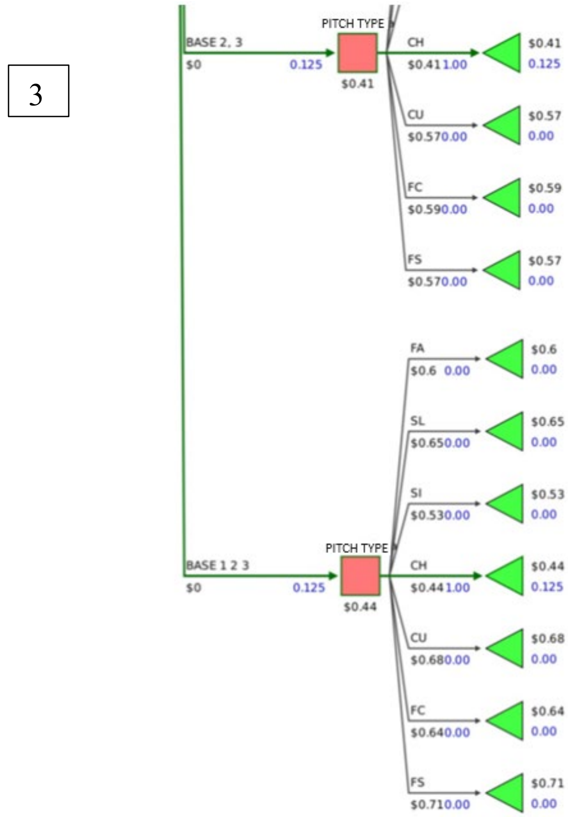

Figure 1: Simplified decision tree with the expected payment of each pitch. First the condition of the field is described with the number of the base that is occupied by a teammate, following the type of ball that the pitcher can choose. Finally, the expected bases conceded by the pitcher's team is presented next to it's probability of occurring.

After running the model, we obtain the results of the decision tree, which in our case indicates the type of pitch to make for each of the 8 game situations when the batter is Acuña. These are:

- When there are no players on any base, a Changeup (CH) is used.
- When there is a player on Base 1, a Changeup (CH) is used.
- When there is a player on Base 2, a Changeup (CH) is used.
- When there is a player on Base 3, a Fourseam (FA) is used.
- When there are two players, one on Base 1 and another on Base 2, a Changeup (CH) is used.
- When there are two players, one on Base 1 and another on Base 3, a Changeup (CH) is used.
- When there are two players, one on Base 2 and another on Base 3, a Changeup (CH) is used.
- When there are 3 players, one on each Base 1, 2, and 3, a Changeup (CH) is used.

We can see that Acuña is not very good at dealing with the Changeup (CH) type of pitch; however, if one seeks to avoid being repetitive with the pitches throughout the game, the second-best option or even the third can be used.

6. Validation

To prove the accuracy of the model, we selected a random baseball match where Ronald Acuña Jr played and compare the results in game with the alternative of the decision tree. The validation was made using the Mets vs. Braves match of April 9th of 2024, that day Acuña challenged three of the opposite pitchers: Adrian Houser, Dedniel Nuñez and Cole Sulser. The first one appeared three consecutive times and threw a total of 9 times, while the other two matchup Acuña one time each, but only Nuñez was able to pitch two balls. The Table 3 show the results, considering the association as follows: (AH) for Adrian Houser, (DN) for Dedniel Nuñez, (CS) for Cole Sulser and Ronadl Acuña as (RA).

Table 3. Ronald Acuña's participation in the Mets vs. Braves match of April 9th. Includes the pitcher he was matched up, the type of pitch he chose, and the result of each one. Also, some information of the ball when it was thrown and hit, is deployed.

AB	#Pitch	Pitcher	Batter	Pitch Type	Game Result	Vel	Spin	Pitch Result	EV	LA	Dist
4	1	(AH)	(RA)	Sinker	Hit by pitch	91.2	2065				
21	1	(AH)	(RA)	Slider	In play, no out	79.9	2132	Single	104.6	13	235
35	1	(AH)	(RA)	Changedup	Foul	83.7	1470				
35	2	(AH)	(RA)	4-seam	Swinging Strike	91.7	2064				
35	3	(AH)	(RA)	4-seam	Ball	92.3	2048				
35	4	(AH)	(RA)	Curveball	Foul	78.9	2028				
35	5	(AH)	(RA)	Sinker	Ball	91.7	2045				
35	6	(AH)	(RA)	Changeup	Ball	83.2	1464				
35	7	(AH)	(RA)	Sinker	Ball	91.8	2149				
50	1	(DN)	(RA)	4-seam	Foul	98	2282				
50	2	(DN)	(RA)	Slider	In play, no out	86.7	2527	Single	78.5	-47	3
71	1	(CS)	(RA)	Cutter	In play, out(s)	87.2	2270	Flyout	81.4	49	229

With the information collected from the match presented on Table 3, we can start a comparison between the real performances of Ronald Acuña Jr. and the ones we predicted. In this case the first throw was not considerer because a pitch mistake led to a base to Acuña without hitting the ball. In the next two turns at bat where Acuña participated, there were no other teammates at the field and faced five different types of pitch, but only three ended up on a miss by Acuña, one of them was a Changeup throw, a result that matches the decision tree forecast. On the other hand, the Fourseam and the Curveball, despite they were not selected by the algorithm, also prove the importance of not being repetitive and try to surprise the pitcher to force the mistake.

For the following matchup, Acuña faced one Fourseam, and one Slider with two teammates on the first two bases of the field, but only connected on the second one. The results partially match the decision tree, because a Slider pitch is not recommended for Acuña as he is very accurate for that throw, however, the Fourseam ball shown a really good performance against Acuña, at least in this match.

Finally, the last at bat turn was played with no other Braves player but Acuña on the field. He faced a Cutter ball, one of the recommendations of the decision tree that led to a direct out of the batter, a positive ending that shows a good performance of the model. Notwithstanding, a further analysis in game could help the model to adjust and improve the accuracy of the forecasting.

7. Conclusion

This project successfully combines quantitative analysis and baseball strategy to enhance our understanding of how to face challenging hitters like Ronald Acuña Jr. Through an approach that included significant factors in pitching, such as game context, hitter efficiency, and pitch selection. The decision tree compiles all relevant information to make the most accurate decisions.

The results showed that, for the larger part of analyzed game situations, the Changeup (CH) pitch is the most effective type of pitch against Acuña. This reveals a performance tendency that can be strategically exploited by opposing teams. Nevertheless, it is important to recognize that the top hitters of the league will recognize the pattern, suggesting the possibility of switching between the second or third-best pitch to keep some level of uncertainty for batters and continue with an efficient strategy.

The project not only has provided an advanced analytical tool to improve pitchers' decisions in specific situations against Acuña but has also contributed to general acknowledge about dynamics y tactics in professional baseball. This quantitative approach highlights the importance of data analysis in sports that has been growing the past few years, showing its potential to improve strategy and on-field performance. In addition, the same analysis can be done with any other player within the MLB database or anyone with enough information about.

Acknowledgement

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References

Baseball Savant. Ronald Acuña Jr. Stats: Statcast, Visuals & Advanced Metrics, 2024, Available: https://baseballsavant.mlb.com/savant-player/ronald-acuna-jr-660670?stats=splits-r-hitting-mlb&season=2023, Accessed on April 15, 2024.

Baseball Savant. Statcast Game Feed & Advanced Metrics. Available: baseballsavant.com. https://baseballsavant.mlb.com/gamefeed?gamePk=747138&game_date=4/9/2024&date=4/9/2024, Accessed on April 15, 2024.

Bonsor, K. and Martin, J., How Baseball Works, Available: https://entertainment.howstuffworks.com/baseball.htm, Accessed on November 13, 2023.

FanGraphs. Ronald Acuña Jr. - Splits - 2023 – Batting, 2023, Available: https://www.fangraphs.com/players/ronald-acuna-jr/18401/splits?position=OF&season=2023, Accessed on November 21, 2023.

International Experience. Cómo se juega al beisbol y sus reglas | United States. International Experience, Available: https://international-experience.es/blog/beisbol-deporte-estados-unidos-reglas/, Accessed on November 13, 2023.

MLB.TTsports. *MLB New York Mets vs Atlanta Braves FULL GAME - 09.04.2024* [Video], Available: YouTube. https://www.youtube.com/watch?v=sT7P04tBMCc, Accessed on April 15, 2024

MLB. Pitch types | Glossary | MLB.com., Available: https://www.mlb.com/glossary/pitch-types, Accessed on November 13, 2023.

Ronald Acuña Jr. Estadísticas, edad, posición, estatura, peso, fantasía y noticias. Lasmayores.com, Available: https://www.mlb.com/es/player/ronald-acuna-jr-660670?stats=career-r-hitting-mlb&year=2023, Accessed on November 21, 2023.

Ronald Acuña Jr. Stats Overview, Available: https://www.baseballprospectus.com/player/105454/ronald-acuna-jr/, Accessed on November 21, 2023.

Woodward, First N., A Decision Tree Approach to Pitch Prediction, Available: https://tht.fangraphs.com/a-decision-tree-approach-to-pitch-prediction/, Accessed on November 21, 2023.

Biographies

Guillermo San Roman is a student at the Universidad Iberoamericana and is pursuing a Bachelor of Science in Industrial Engineering. He participated in the state of Mexico math competition after winning a competition in the municipality of Ixtapan de la Sal, he speaks English and Spanish and is currently learning Japanese.

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Isidro Soria is a Coordinator for the Industrial Engineer Bachelor degree at Universidad Iberoamericana in Mexico City. He obtained his Master's degree in Science and PhD in Industrial Engineering, and a Specialization in Japanese Production System and Education in Japan. Isidro has worked in the field in the areas of consultancy, supply chain strategy, logistics and network optimization. His research interests are optimization and distribution networks for industry problems.