fRisbee: An Open-Source Package for College and Professional Ultimate Frisbee Data and Modeling

Ben Wieland and Akiva Dienstfrey, University of Virginia

I. Introduction

The popularity of Ultimate Frisbee is skyrocketing: over 650 collegiate men's and women's teams competed in the 2021-22 season, and the American Ultimate Disc League continues to expand, with the addition of three new franchises for the 2021-22 season (AUDL 2021). This increase in popularity demands an increase in available data. `fRisbee` is an open-source R package designed to create a fast and accessible way to access collegiate and professional men's and women's Ultimate Frisbee rankings, results, and historical data. The package provides ease of access to previously inaccessible datasets, including access to aggregated game-by-game information on over 5,400 Ultimate Frisbee matches at the collegiate level during the 2021-22 season; it also includes web scraping functions to access up-to-date results and data.

The package also makes Ultimate Frisbee predictive modeling simple: it comes equipped with two pre-trained and easily deployable models for win probability and margin of victory projections, and includes easy access to the aforementioned historical data repositories for users to train and fit their own models. This increased data access will provide benefits at every level of the sports: fans will find it easier to follow their favorite teams, coaches and players will have the tools at their fingertips to make informed, data-driven decisions, and analysts will find it easier to aggregate and evaluate statistics regarding the sport.

`fRisbee` is currently in the process of submitting to CRAN. Once that process is completed, the package will be installable using `install.packages("fRisbee")`; however, the current version of the package should be installed directly from its GitHub repository. Once the package is installed, it can be loaded using `library(fRisbee)`.

```r
# Run the below line if necessary:
# devtools::install_github("https://github.com/bbwieland/fRisbee")

library(fRisbee)
```

II. Collegiate Data Access

Two of the most useful tools included in `fRisbee` are the `load_rankings_men()` and `load_rankings_women()` functions. In tandem, these functions provide a top-level overview of every team in college frisbee. They include up-to-date biographical information, including team division, conference, and region, as well as up-to-date information on team performance, such as record, rating, and national ranking. The functions are built around the frisbee-rankings website, developed by Cody Mills (Mills 2022).

They also allow for filtering to include only Division I teams, as well as a "simple table" format that includes only the most pertinent columns for a true at-a-glance view of each team.

```r
fRisbee::load_rankings_men() %>%
  str()
```

```
## tibble [403 x 11] (S3: tbl_df/tbl/data.frame)
##  $ Rank      : num [1:403] 1 2 3 4 5 6 7 8 9 10 ...
##  $ RegionRank: chr [1:403] "NE 1" "AC 1" "SC 1" "NW 1" ...
##  $ Team      : chr [1:403] "Brown" "North Carolina" "Colorado" "Brigham Young" ...
##  $ Record    : chr [1:403] "38-2" "43-3" "30-2" "22-1" ...
##  $ WinPct    : num [1:403] 0.95 0.935 0.938 0.957 0.735 ...
##  $ Rating    : num [1:403] 2210 2179 2145 2039 1999 ...
##  $ Region    : Factor w/ 11 levels "New England",..: 1 2 3 4 5 6 1 7 1 6 ...
##  $ Conference: chr [1:403] "Greater New England DI" "Carolina DI" "Rocky Mountain DI" "Big Sky DI" .
##  $ Division  : Factor w/ 4 levels "D-I","D-III",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ SoS       : num [1:403] 1826 1754 1763 1557 1788 ...
##  $ PDC       : num [1:403] 384 425 382 482 211 ...
```

This data is useful for observing overall trends across collegiate Ultimate Frisbee; given the dearth of media coverage provided to the sport outside of a limited few publications, this accessibility makes understanding the sport for those new to its format easier, while also allowing for more in-depth analysis of trends at the team or conference level by expert Ultimate Frisbee fans, players, and coaches.

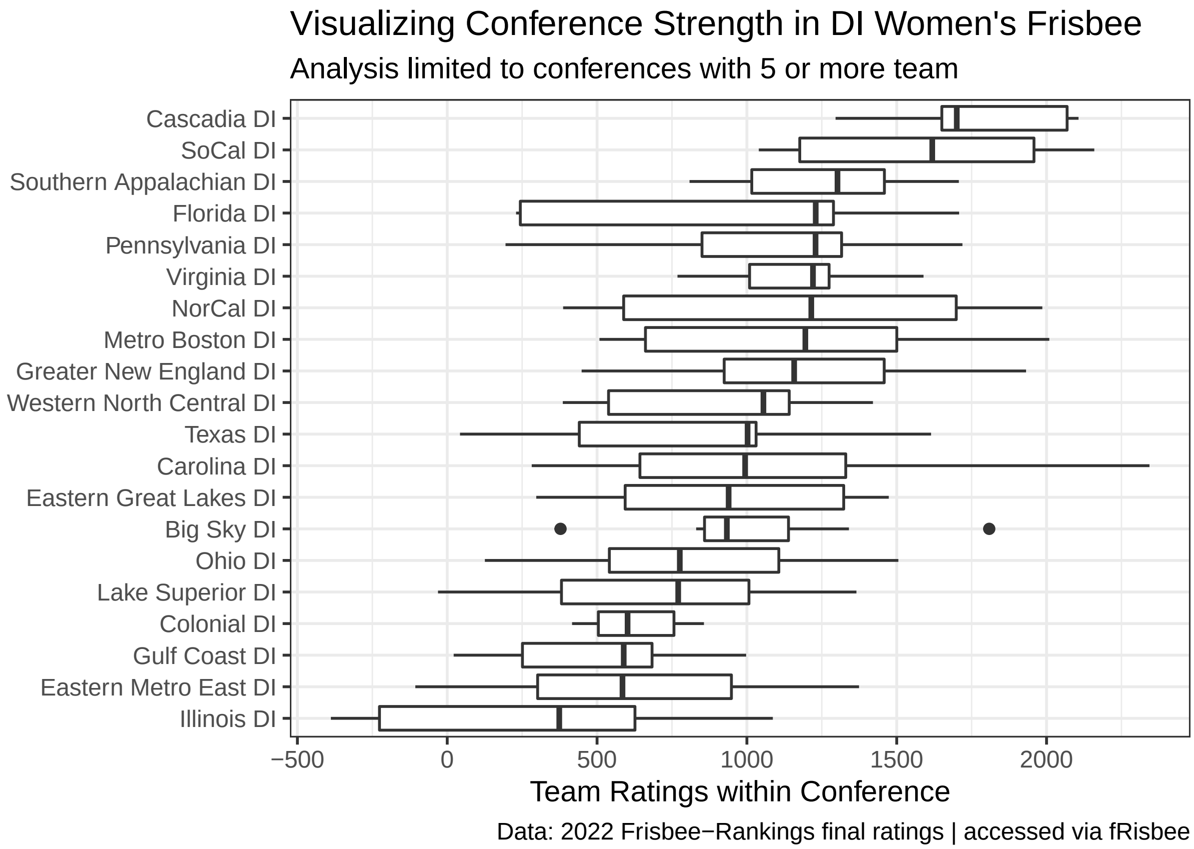
Example: Team strength can vary greatly across conferences in college athletics, due to disparities in program funding and appeal to incoming high school recruits. Ultimate is no exception: the most competitive conferences can have average team ratings that double those of the least competitive conferences. fRisbee makes it easy to evaluate the strength of each conference, utilizing the `load_rankings_men()` and `load_rankings_women()` functions.

The example plot below showcases these differences, along with a few other interesting idiosyncrasies. For example, North Carolina — the top-ranked team last season — jumps off the page from the Carolina conference. BYU was also the strongest program in the Big Sky conference by far in 2022.

```r
# These packages are necessary for the example below.
library(dplyr)
library(ggplot2)

# Use fRisbee to access up-to-date women's team rankings
teams = fRisbee::load_rankings_women(DivisionIOnly = T)


teams %>%
  # Calculate the median conference rating & the number of teams in each conference
  dplyr::group_by(Conference) %>%
  dplyr::mutate(AvgConfRating = median(Rating),
                TeamsInConf = n()) %>%
  dplyr::ungroup() %>%
  # Filter to include only conferences with 5 or more teams
  dplyr::filter(TeamsInConf >= 5) %>%
  # Create the boxplot display
  ggplot2::ggplot(aes(x = Rating, y = reorder(Conference, AvgConfRating))) +
  ggplot2::geom_boxplot() +
  # Add labeling and themes
  ggplot2::labs(x = "Team Ratings within Conference",
                y = "",
                title = "Visualizing Conference Strength in DI Women's Frisbee",
                subtitle = "Analysis limited to conferences with 5 or more team",
                caption = "Data: 2022 Frisbee-Rankings final ratings | accessed via fRisbee") +
  ggplot2::theme_bw()
```



Team-level collegiate data is also available within the `fRisbee` package. The `load_team_results_men` and `load_team_results_women` functions provide full information on every team result in the current season, which is initially uploaded to USA Ultimate's website (USAUltimate 2022). They make it easy to visualize a team's performance over the course of a season at a glance, including raw data (the score for each team, the game result, etc.) as well as additional informational data to contextualize the matchup (the opposing team's ranking, the event the game was played at, etc.). Also included is information on the team's rating before and after the game was played, making it easy to tell if a team outperformed expectations and saw a rating increase or underperformed expectations and saw a rating decrease as a result of the match.

```r
fRisbee::load_team_results_men("Virginia") %>%
  str()
```

```
## tibble [32 x 21] (S3: tbl_df/tbl/data.frame)
##  $ OppRk              : num [1:32] 16 62 30 25 48 41 67 93 57 27 ...
##  $ Opponent           : chr [1:32] "Michigan" "Carnegie Mellon" "North Carolina-Wilmington" "Maryland
##  $ Result             : chr [1:32] "Loss 5-12" "Win 11-6" "Win 11-7" "Loss 10-12" ...
##  $ Effect             : num [1:32] -7.59 10.16 13.72 -2.45 1.92 ...
##  $ Status             : Factor w/ 2 levels "Counts","Ignored": 1 1 1 1 1 1 1 1 1 1 ...
##  $ PctOfRanking       : num [1:32] 0.0241 0.0238 0.0245 0.0252 0.0252 0.0252 0.0282 0.0282 0.0282 0.0
##  $ Date               : Date[1:32], format: "2022-02-12" "2022-02-12" ...
##  $ Event              : chr [1:32] "Queen City Tune Up 2022" "Queen City Tune Up 2022" "Queen City Tu
##  $ Win                : num [1:32] 0 1 1 0 1 0 1 1 1 0 ...
##  $ Pts                : num [1:32] 5 11 11 10 13 8 15 15 14 10 ...
##  $ OppPts             : num [1:32] 12 6 7 12 12 15 9 12 13 15 ...
##  $ GameScore          : num [1:32] -600 547 467 -238 125 ...
##  $ PtDiff             : num [1:32] -7 5 4 -2 1 -7 6 3 1 -5 ...
```

```
## $ OpponentRating    : num [1:32] 1808 1385 1595 1658 1464 ...
## $ TeamRatingPostgame: num [1:32] 1522 1505 1501 1517 1513 ...
## $ GameValue         : num [1:32] 1208 1932 2062 1420 1589 ...
## $ TeamRatingPregame : num [1:32] 1530 1495 1487 1520 1511 ...
## $ GameValueUsed     : num [1:32] 1208 1932 2062 1420 1589 ...
## $ RatingsImpact     : num [1:32] 29.1 46 50.5 35.8 40.1 ...
## $ Team              : chr [1:32] "Virginia" "Virginia" "Virginia" "Virginia" ...
## $ GameNum           : int [1:32] 1 2 3 4 5 6 7 8 9 10 ...
```

These data are useful from a variety of perspectives. For fans, it can be interesting to follow a team's ups, downs, and general performance at various points throughout the season.

III. Historical Collegiate Data

One key issue with publicly available collegiate Ultimate Frisbee data is the inaccessibility of results, rankings, and standings from previous seasons. While individual tournament results can sometimes be cobbled together from a variety of tournament websites and social media posts, there is no collective source for viewing past results in a structured and organized way.

`fRisbee` aims to change that, beginning with data from the 2021-22 season. In addition to functionality for scraping up-to-date current results, the package will also contain information on past results. By periodically performing in-season web scrapes and saving the data to an outside database, `fRisbee` can be instrumental in documenting the history of college Ultimate Frisbee over time.

The historical data currently available within the package is very limited in scope, including only games between top 100 teams during the 2021-22 season. This data is accessible directly via the `fRisbee` package as two dataframes: `gamesM` and `gamesW`. The data is game-level, and stored in the same format as the output from the `load_team_results_` family of functions.

In the future, data will be collected and stored on all games (not just those between top-100 foes) and made accessible through the package in a style similar to `nflreadr` (Ho and Carl 2022).

```
fRisbee::gamesW %>%
  head(3)
```

```
## # A tibble: 3 x 21
##   OppRk Oppon~1 Result Effect Status PctOf~2 Date       Event   Win   Pts OppPts
##   <dbl> <chr>   <chr>   <dbl> <fct>    <dbl> <date>     <chr> <dbl> <dbl>  <dbl>
## 1    12 Brigha~ Win 1~   2.35 Counts  0.0347 2022-02-12 Quee~     1    11      5
## 2    49 Columb~ Win 1~   0    Ignor~  0      2022-02-12 Quee~     1    12      3
## 3    34 Michig~ Win 1~   0    Ignor~  0      2022-02-12 Quee~     1    11      4
## # ... with 10 more variables: GameScore <dbl>, PtDiff <dbl>,
## #   OpponentRating <dbl>, TeamRatingPostgame <dbl>, GameValue <dbl>,
## #   TeamRatingPregame <dbl>, GameValueUsed <dbl>, RatingsImpact <dbl>,
## #   Team <chr>, GameNum <int>, and abbreviated variable names 1: Opponent,
## #   2: PctOfRanking
```

IV. USA Ultimate Algorithm Implementation

College Ultimate Frisbee is unique among collegiate sports in its utilization of an algorithm alone to determine postseason bids. While major sports such as football and basketball have selection committees for the College Football Playoff and March Madness, respectively, wild-card bid allocation for the USAU College Championships is conducted solely based on the 'USAU Ultimate Rankings' (USAUltimate 2018).

The team ratings are the average of a team's game ratings. Each game rating is a function of the opponent's rating in that game, as well as the team's performance in the game.

The formula for computing team performance rating for a given game is as follows.

First, a score difference proportion r is computed.

$r = \frac{losing\ score}{winning\ score - 1}$

Then, that value is passed into a formula for calculating the performance rating:

$diff = 125 + 475 \frac{sin(min(1, \frac{1-r}{0.5}) * 0.4\pi)}{sin(0.4\pi)}$

This formula is designed for a few specific properties: every one-goal game has a value of 125, goal differences are "worth" more rating points in close games than blowouts, and the maximum possible performance rating is 600, which can be obtained only in games where a team doubles their opponent's score.

To calculate a final game rating, that performance rating is added to the opponent's pregame rating.

$FinalRating = pregame + diff$

A team's season-long rating is calculated as a weighted average of their game ratings, designed to prioritize recent games and remove the impact of games with extreme differences in competition.

This algorithm proves useful for teams to know exactly how well they need to play to earn a wild-card bid to the college championships, and requires them to play at a high level even in games against weaker competition; a win does not guarantee a rating increase! However, its complexity makes it difficult to use on the fly; the last thing a coach wants to be doing mid-tournament is computing trigonometric functions on the sideline. The `calculate_` family of functions within `fRisbee` makes these calculations easy and accessible, and can be easily implemented via Shiny app or another interface for quick use. There are three key functions within the family, each designed for a different use case:

1. `calculate_game_score` calculates the performance rating for a winning team, given the winning and losing score:

```
calculate_game_score(15,11)
```

```
## [1] 381.1648
```

2. `calculate_game_score_adjusted` takes as arguments not just the winning and losing scores, but also the initial ratings of the winning and losing teams. From this, it calculates the final rating impact of a game in the `Difference` column; this column is a sum of the `Initial` column (the opponent rating) and the `GameScore` column (the performance rating). In the below example, the winning team wins a close game 15-14 despite entering the game as a heavy 800 rating point favorite. As a result, the winning team actually experiences a decrease in their overall rating due to the outcome; this is an important quirk of the USAU formula that differentiates it from standard Elo ratings, where a team's rating never decreases with a win or increases with a loss.

```
calculate_game_score_adjusted(1800,1000,15,14)
```

```
##     Team Initial GameScore Difference Increased
## 1 winner    1800      1125       -675     FALSE
## 2  loser    1000      1675        675      TRUE
```

3. `calculate_game_score_adjusted_team` is similar in structure to `calculate_game_score_adjusted`, with one useful caveat: instead of taking the ratings of the winning and losing teams as inputs, it simply

takes the names of the winning and losing teams, as well as the league type ("mens" or "womens"). Then, it automatically pulls the current rating of those teams using the `load_rankings_` function family. This function is great for answering hypothetical matchup questions; the example answers the question "What would happen to each team's rating if North Carolina's men's team beat Brown's men's team 13-11?"

```r
fRisbee::calculate_game_score_adjusted_team("North Carolina","Brown",13,11,"mens")
```

```
##             Name   Team Initial GameScore Difference Increased
## 1 North Carolina winner 2179.26   2438.63   259.3704      TRUE
## 2          Brown  loser 2209.79   1950.42  -259.3704     FALSE
```

One more function is included in the `calculate_` family, though its functionality is slightly different from the other three: `calculate_win_probability`. This function uses pre-trained logistic regression models within the package to calculate the win probability of a hypothetical game between Team A and Team B, given each team's rating and the league type of the game. The example below computes the win probability for a game between a 1500-rated women's team and a 1300-rated women's team.

```r
fRisbee::calculate_win_probability(1500,1300,"womens")
```

```
## [1] 0.7219515
```

V. American Ultimate Disc League Data

Ultimate is also popular at the semi-professional level, by way of the American Ultimate Disc League. The AUDL plays under a ruleset that differs from USA Ultimate, the administrators of college Ultimate: AUDL fields are larger, have a shorter stall clock (essentially a shot clock for time to throw the disc), and are officiated by referees instead of self-officiated, along with many other differences (Krucoff 2018). However, the fundamental rules and structure of the sport remain the same, and similar data are collected for games played under AUDL and USAU rules.

AUDL data is also accessible via the `fRisbee` package. Three functions are included in the `load_audl_` family for scraping game-level, team-level, and player-level data. In addition, a glossary of AUDL team information such as cities, abbreviations, and logos are made available via the `glossary_AUDL_teams` dataframe. This glossary is particularly useful for data visualization, where team logos can be added to plots to enhance graphics.

1. `load_audl_games` provides game-level data on AUDL matchups. In addition to the actual game results, other useful information about each game is included in these observations, such as the week the game was played, whether the game was a postseason matchup or not, the stadium where the game was played, and the date and time of the game. The game's streaming URL is also provided in the `streamingURL` column, where subscribers to AUDL TV can either watch a game live or view a game replay.

In the example below, `load_audl_games` is used to quickly summarise information about home-field advantage in the AUDL. In the 2022 season, home teams outscored away teams by approximately 1.21 points per game on average.

```r
games = fRisbee::load_audl_games(2022)

# Does home-field advantage exist in the AUDL?
```

```r
games %>%
  # filter to regular season only
  dplyr::filter(substr(week,1,4) == "week") %>%
  # calculating average home & away scores
  dplyr::summarise(avgHome = mean(homeScore),
                   avgAway = mean(awayScore))
```

```
##    avgHome  avgAway
## 1 21.57333 20.36667
```

2. `load_audl_player_stats` provides player-level statistics for each season of AUDL play. These statistics include both basic information — goals, assists, blocks, etc. — and more complex statistics such as offensive efficiency. Statistics can be requested either as season-long totals, per-game averages, or per-10-possession or per-10-points statistics. Each set of statistics is useful for different purposes: the total and per-game statistics are useful descriptors for ranking players, while the per-point and per-possession statistics sacrifice a bit of fungibility to offer a tempo-free and pace-free number that is perhaps more accurate for player evaluation.

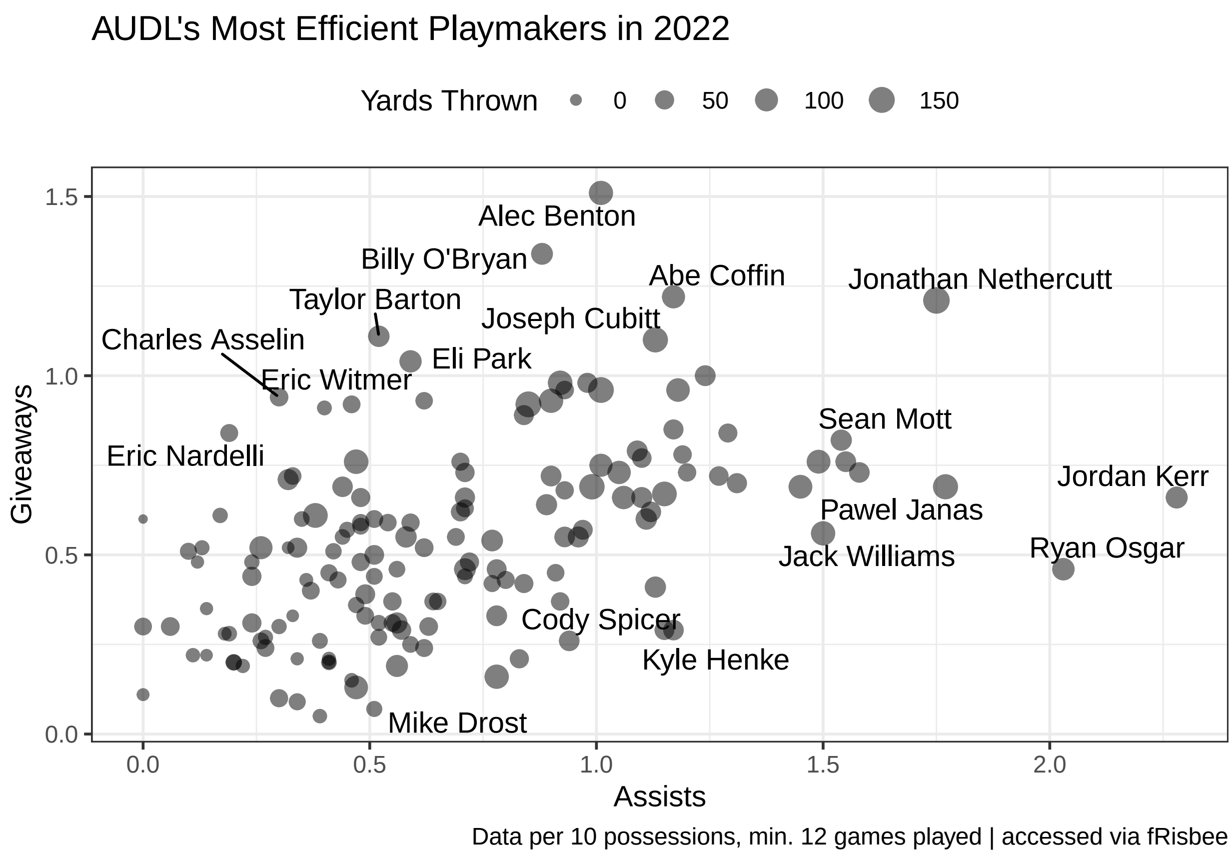
In the example below, per-10-possession data is used to evalute the most efficient playmakers in Ultimate for the 2022 season. Ideally, a good playmaker will create assists at a high rate while infrequently turning the disc over. In this regard, Jordan Kerr and Ryan Osgar stand out from the rest of the pack.

```r
library(ggrepel)

player_stats = fRisbee::load_audl_player_stats(2022, stat_type = "10 possessions")

player_stats_plot = player_stats %>%
  # filtering to players who played in all games
  dplyr::filter(gamesPlayed >= 12) %>%
  # creating a composite "giveaways" stat
  dplyr::mutate(giveaways = throwaways + stalls + drops)

ggplot2::ggplot(player_stats_plot,aes(x = assists, y = giveaways)) +
  # adding points
  ggplot2::geom_point(aes(size = yardsThrown), alpha = 0.5) +
  # adding readable text labels via ggrepel
  ggrepel::geom_text_repel(aes(label = name)) +
  # re-sizing scale of point size
  ggplot2::scale_size_continuous(range = c(1,4)) +
  ggplot2::theme_bw() +
  ggplot2::labs(x = "Assists", y = "Giveaways",
                size = "Yards Thrown",
                title = "AUDL's Most Efficient Playmakers in 2022",
                caption = "Data per 10 possessions, min. 12 games played | accessed via fRisbee") +
  ggplot2::theme(legend.position = "top")
```



3. `load_audl_team_stats` provides access to team-level AUDL statistics by season. Like its sibling function for player-level statistics, `load_audl_team_stats` offers functionality for both total and per-game statistics. It also adds a `team_type` option, which allows for either team or opponent stats to be accessed: `team_type = "team"` will yield points scored, assists recorded, etc. while `team_type = "opponent"` will yield points allowed, assists allowed, etc.

In the example below, `load_audl_team_stats` is utilized in conjunction with the `glossary_AUDL_teams` dataframe included in the package. First, team data from 2022 are accessed and a variable for net rating is created using the formula 'points scored - points allowed'. Then, the glossary including team logos is joined to the team dataset. Finally, the net ratings are plotted in bar chart format and the `ggimage` package is used to plot images of each team's logo at the end of their bar. This chart is just one example of how team logos can be seamlessly implemented into visualizations in R using the `glossary_AUDL_teams` dataframe.

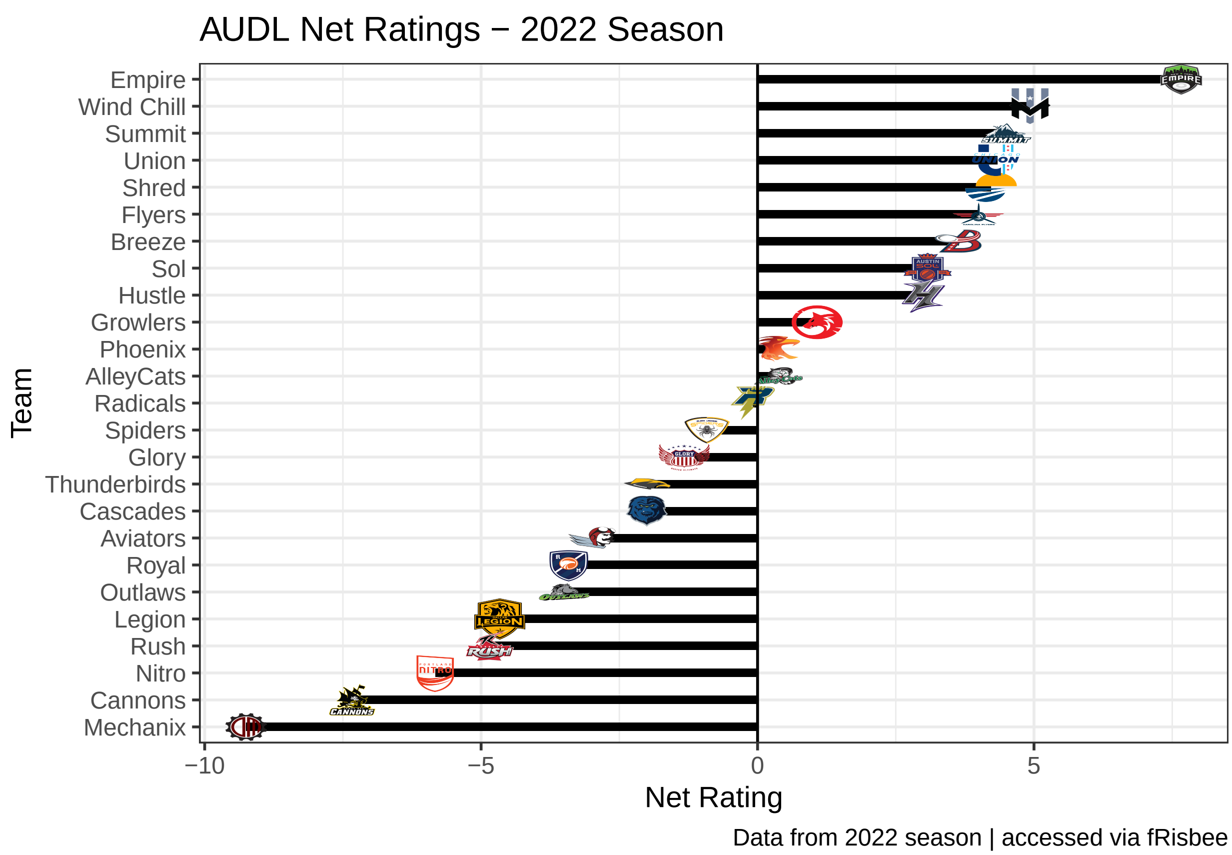
```
library(ggimage)

# scraping stats and creating net rating
team_stats = fRisbee::load_audl_team_stats(2022) %>%
  dplyr::mutate(netRating = scoresFor - scoresAgainst)

# joining the glossary of logos
team_stats_plot = team_stats %>%
  dplyr::left_join(glossary_AUDL_teams, by = "teamName")

ggplot2::ggplot(team_stats_plot, aes(x = netRating, y= reorder(teamName, netRating))) +
  # creating bars
```

```r
  ggplot2::geom_col(fill = "black", width = 0.3) +
  # adding logos
  ggimage::geom_image(aes(image = logoURL)) +
  # creating the anchor line in the middle
  ggplot2::geom_vline(xintercept = 0) +
  ggplot2::labs(x = "Net Rating", y = "Team",
       title = "AUDL Net Ratings - 2022 Season",
       caption = "Data from 2022 season | accessed via fRisbee") +
  ggplot2::theme_bw()
```



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