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# Applying Machine Learning and Convex Optimization to the UFC Betting Market

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## 1 Problem Statement

Mixed martial arts has seen a rapid increase in popularity in mainstream sports, with the Ultimate Fighting Championship (UFC) being one of the largest promotions in the world. Consequently, betting on UFC events has become increasingly prominent, intensified by aggressive marketing and easy-to-use platforms provided by bookmakers like DraftKings and FanDuel.

Betting markets are generally very efficient and the implied probabilities of sportsbooks' odds are often "accurate" in the sense that they match up well with the relative frequency of events occurring. However, bookmakers can offer mispriced odds under/overestimating a fighter's chances of winning, yielding opportunities to generate profit if identified correctly.

This project will be a preliminary exploration into whether or not one can obtain an edge in the UFC betting market by producing well-calibrated probabilities for fight outcomes and formulating an optimization problem to calculate optimal wager sizes using those predicted probabilities.

Past work related to this has largely focused on using rather generic and easily accessible data from the UFC Stats website; we will consider more niche and unconventional datasets from third-party websites, a novel approach relative to public research on forecasting UFC fights.

## 2 Approach

Our approach will consist of the following components:

1. *Alternative Data* - We will be web scraping a wide variety of data from several disparate sources, some of which are niche and contain information that can't be found anywhere else. See [section 3](#) for details on each source.
2. *Feature Engineering* - Creating a rich feature set will likely be the most time-consuming and challenging part of this project as most of the scraped data is unusable without some transformation and aggregation. Additionally, this will require creativity, experimentation, and a deep understanding of the UFC sport to produce the most correlating set of features. Care will be taken to prevent data leakage, ensuring all features are constructed using information known strictly before a fight occurs.
3. *Modeling* - We will experiment with logistic regression, random forest, and gradient boosting models with the goal of producing well-calibrated win probabilities for fights, given our engineered features.

4. *Bet Sizing* - We extend the Kelly criterion for optimal bet sizing to a general number of simultaneous bets. Given there are  $n$  fights in an upcoming event and restricting to moneyline straight bets (no parlays, spreads, or over/under bets), there exist  $2n + 1$  potential positions—two outcomes for each fight and a risk-free asset (no bet). Maximizing for expected log wealth, we can formulate this as the following optimization problem:

$$\begin{aligned} \max_b \quad & \pi^T \log(Rb) \\ \text{s.t.} \quad & 1^T b = 1 \\ & b \succeq 0 \end{aligned}$$

where  $\pi \in \mathbb{R}^{2^n}$  is a vector of probabilities corresponding to each of the  $2^n$  different event outcomes,  $R \in \mathbb{R}^{2^n \times (2n+1)}$  is the returns matrix encoding the returns for each of the  $2n + 1$  positions for each of the  $2^n$  outcomes, and  $b \in \mathbb{R}^{2n+1}$  is a vector of wager proportions for each bet. This problem is always feasible: in the worst case, take  $b^* = e_{2n+1}$ , the  $(2n + 1)$ -th basis vector in  $\mathbb{R}^{2n+1}$ , which is equivalent to not betting at all and guarantees a profit/loss of 0. Since  $\pi$  is intractable, we can estimate  $\hat{\pi}$  using the predicted probabilities from our classifier (given it is well-calibrated) and assuming independence of fights within an event.

5. *Backtesting* - Finally, we will evaluate and compare our models' betting performance on unseen fights from 2022 through 2024 given average closing odds, which reflect the most information and are therefore the "sharpest" lines. Caution will be taken to prevent leakage and all fights will be considered, including those that ended in draws or no contests, to simulate bets that may be voided and thus preserve realism.

### 3 Data

This project will leverage data from the following sources:

- **UFC Stats** - Mainstream analytics website for the UFC that contains per-round fight statistics regarding aspects like striking and takedowns as well as fighter characteristics such as height and reach
- **Sherdog** - Third-party website not affiliated with the UFC that acts as a database for 300,000+ fights across multiple professional and amateur promotions; has information on UFC fighters' full professional careers including fights before signing with the UFC and extra data like nationalities
- **Fight Matrix** - Third-party website that uses Sherdog's data and proprietary algorithms to maintain a custom ranking system and Elo-like ratings
- **FightOdds.io** - Historical and upcoming betting odds across several bookmakers
- **Open-Elevation API** - Open-source API for getting elevation data rounded to the nearest meter for a given set of latitude and longitude coordinates

This is a good way of demonstrating our approach since we will be considering many different kinds of data, offering room to be creative in the feature engineering process. Data scarcity will also not be a large issue, since the training set will contain several thousand fights. Moreover, the historical closing odds will allow us to get realistic and conservative estimates of betting performance.

## **4 Success Metrics**

Success will be determined in terms of how the models compare to closing odds as well as the profitability of each pipeline. Since closing lines theoretically capture the most information known before a fight, we would ideally like to achieve a log loss as close as possible to or even better than the bookmakers' implied probabilities—no worse than a 0.05 difference could be a starting point. For profitability, success would be a positive return over the backtesting period.

## **5 Milestones and Deliverables**

Major milestones for the project are as follows:

1. Collect and maintain a complete UFC dataset from mainstream and third-party sources
2. Create candidate features/sets of features for each data source
3. Train and save logistic regression, random forest, and gradient boosting models
4. Evaluate and compare log loss and betting performance of models on fights from 2022 through 2024

Deliverables will include a complete UFC dataset, trained and saved models, a performance comparison between the models and the closing odds for the backtest period as well as each other, and an evaluation of betting returns on that same period.