**Research Document**

(Domain Understanding and Explainable AI)

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# **Explainable AI**

## **1. Main Research Questions**

### **1.1 What is Explainable AI?**

**Explainable Artificial Intelligence** (XAI) refers to a set of methods, techniques, and principles that make the inner workings and decision-making processes of machine learning models **transparent and understandable to humans**. Traditional “black box” models can make accurate predictions but often do so without offering insight into why a certain outcome was predicted. XAI aims to close this gap by providing **human-interpretable explanations**.

In this project, XAI is used to make predictions about League of Legends match outcomes understandable, not just determining **who will likely win**, but **why the model thinks so**, based on pre-game and early-game data.

### **1.2 Why is Explainable AI Important?**

Explainable AI plays a crucial supporting role in making **predictive models more reliable**, **interpretable, and actionable**. Some key reasons include:

* **Transparency:** Explanations reveal the reasoning behind model outputs, helping stakeholders understand the **decision-making process.**
* **Trust and Adoption:** When users can see *why* a model made a prediction, they are **more likely to trust and use it**.
* **Debugging and Improvement:** Explanations can highlight whether a model relies on **meaningful signals** or on **misleading patterns**.
* **Communication:** Clear explanations make it easier to share insights with **non-technical audiences**, such as players, coaches, or spectators.
* **Ethical and Responsible Use:** Explainability contributes to fairness, accountability, and compliance with **standards and regulations**.

In short, XAI turns predictions from “**numbers on a screen**” into **understandable concepts**  that people can interpret and act on.

### **1.3 Which Aspects of Explainable AI Are Important?**

The field of XAI is broad, but for this project, several aspects are particularly relevant:

* **Global Explanations:** Identify which features are most influential on average (e.g., gold difference, objectives).
* **Local Explanations:** Explain individual predictions (e.g., why a specific team has 78% win probability).
* **Intrinsic vs. Post-hoc Explanations:**
  + **Intrinsic:** Transparent models like decision trees or linear models.
  + **Post-hoc:** Applied after training black-box models using SHAP, LIME, or counterfactuals.
* **Visualization & Communication:** Feature importance plots, SHAP summary graphs, textual summaries to communicate insights effectively.

In games, SHAP values and tree-based feature importance are especially useful for tabular pre-game and early-game features.

### **1.4 How Does Explainable AI Apply to This Project?**

The core of this project is predicting the outcome of ranked League of Legends matches based on pre-game team composition and early-game state. **Explainable AI** supports this by making the model’s reasoning transparent and actionable.

For example:

* A global explanation might show that *team gold difference, first tower, and objectives secured* are the most predictive features across all matches.
* A local explanation could clarify why the model gave a specific team a 78% win probability: e.g. because they had a 2k gold lead, secured the first tower, and have more objectives secured
* Post-hoc methods like SHAP can be applied to complex models (e.g., gradient boosting) to explain both overall trends and individual predictions.

These insights can then be communicated in ways relevant to different stakeholders:

* Coaches: Strategic factors and objective control.
* Players: Performance indicators and decision-making impact.
* Viewers and Analysts: Intuitive summaries to understand the current game state.

By integrating XAI, the project not only predicts match outcomes but also explains the underlying “why” - making the results interpretable, educational, and practically useful.

### **1.5 Research Subquestions**

To explore the role of **Explainable AI** in this context, the following research sub questions will guide this project:

1. How can explainable AI methods be applied to understand and interpret model predictions of League of Legends match outcomes?
2. Which XAI techniques (e.g., SHAP, LIME, global feature importance, interpretable models) provide the most useful and clear explanations for this domain?
3. How can explanations be presented to different audiences (e.g., coaches, players, viewers) to support decision-making and understanding?
4. How does the choice of model (inherently interpretable vs. black box with post-hoc explanations) affect the balance between predictive accuracy and interpretability?
5. Can using XAI uncover new, previously overlooked patterns or factors that contribute to match outcomes, potentially informing strategy or further research?

### **1.6 Pros and Cons of Explainable AI**

Based on my research into Explainable AI, I identified several key **pros** and **cons** that are relevant to this project. Understanding these factors helps clarify both the **potential benefits** of applying XAI methods and the **practical challenges** that may arise during implementation.

**Pros**

* **Improved Transparency:**  
  XAI reveals how models make decisions, making it easier to understand and justify predictions.
* **Increased Trust and Adoption:**  
  Users are more likely to rely on model outputs when they can see clear explanations, especially in competitive or strategic domains like esports.
* **Debugging and Model Improvement:**  
  Explanations can highlight when a model relies on unexpected or misleading features, enabling targeted refinement.
* **Actionable Insights:**  
  By identifying key features and interactions, XAI can uncover patterns that inform strategies, decision-making, or further analysis.
* **Adaptable Communication:**  
  Explanations can be tailored to different audiences (technical vs. non-technical), improving accessibility of AI outputs.

**Cons**

* **Additional Complexity:**  
  Implementing XAI methods can add extra steps to the modelling pipeline, requiring careful selection and interpretation of techniques.
* **Risk of Misinterpretation:**  
  Explanations might be oversimplified, leading stakeholders to draw incorrect conclusions if not communicated properly.
* **Trade-off with Model Accuracy:**  
  Simpler, interpretable models are often less accurate, while more accurate black-box models may need complex explanations.
* **Scalability and Performance Costs:**  
  Techniques like SHAP can be computationally expensive, especially on large datasets or complex models.
* **Not Always “Truly” Explaining:**  
  Some methods provide *approximations* of model reasoning rather than the exact internal logic, which can lead to misleading explanations if not applied carefully.

**1.7 Explainable AI Across Domains**

While this project focuses on applying Explainable AI (XAI) within the context of games, particularly *League of Legends*, it is valuable to understand how XAI operates across different domains such as science, engineering, and healthcare. Each field has unique requirements for interpretability, transparency, and reliability, which highlight both the strengths and limitations of explainable systems.

**AI in Games**

In games, Artificial Intelligence is used in multiple ways - not only to predict outcomes, but also to control non-player characters (NPCs), adjust game difficulty, and enhance player engagement through adaptive systems.

* **NPC Behavior and Decision-Making:**  
  AI drives how non-player characters behave, react, and interact with the player. Explainable AI can clarify *why* an NPC took a specific action or made a certain decision, improving debugging, game balancing, and player understanding. For example, developers could use XAI to visualize how an NPC prioritized certain actions based on the player’s position or threat level.
* **Dynamic Difficulty Adjustment (DDA):**  
  Some games use AI to automatically adjust difficulty levels based on player performance. XAI can help explain these adjustments - showing which factors (accuracy, completion time, errors, etc.) led the system to make the game easier or harder. This transparency improves player trust and perceived fairness.
* **Predictive and Analytical AI:**  
  In competitive or data-driven games like *League of Legends*, AI can predict match outcomes, analyze player behavior, and highlight key performance indicators. Here, XAI explains *why* the system expects one outcome over another, bridging the gap between data analysis and strategic insight.

Overall, XAI in games helps build trust between players and systems, supports developers in tuning game logic, and offers educational insights into complex gameplay dynamics.

**AI in Science/Engineering**

In contrast, fields such as science and engineering use XAI to make data-driven predictions transparent - for instance, explaining results from simulations, experiments, or optimization models. These explanations are vital for ensuring safety, reliability, and accountability in critical environments.

For example, in engineering, XAI can clarify *why* a predictive maintenance model flagged a machine component as faulty, while in medicine, it can justify why an AI model suggested a certain diagnosis.

The main challenge in these fields lies in maintaining a balance between model accuracy and interpretability. Deep learning models often provide high performance but limited transparency, whereas simpler interpretable models may be easier to understand but less precise.

**Comparison and Relevance to This Project**

Across domains, XAI shares a common goal: bridging the gap between AI reasoning and human understanding.  
However, the focus varies:

* In games, explainability supports *learning, balance, and fairness*.
* In science and engineering, it ensures *safety, validation, and reproducibility*.

# **Domain Understanding**

## **2. Context: What is League of Legends?**

League of Legends is a competitive team-based game in which two teams of five players, Blue side and Red side, compete to destroy the enemy’s Base (Nexus). The map is divided into three lanes (Top, Mid, and Bottom) and a Jungle area with neutral objectives. Each player fulfills a distinct role:

* Top lane: Typically durable champions or split-pushers (focusing on one lane when the team fight on another lane)
* Jungle: Controls neutral objectives and creates pressure across the map.
* Mid lane: Has high map impact through central positioning and roaming (going to other lanes to help)
* ADC (Bot): The ranged damage dealer, scaling heavily with items.
* Support: Provides vision, crowd control, and protection.

## **3. Core Concepts and Their Importance**

Several measurable factors are central to understanding match outcomes:

* **Creep Score (CS):** The number of minions or monsters killed. Higher CS generates more gold and accelerates item purchases.
* **Gold:** The primary currency used to buy items. Team gold difference is one of the strongest indicators of victory.
* E**xperience (XP) and Levels:** Levels increase champion power and grant ultimate abilities. Even a single level advantage can decide early fights.
* **Kills, Deaths, Assists (KDA):** While important, kills often matter most because they lead to turret plates (extra gold) and objectives.
* **Objectives:**
  + **First Blood:** A helpful boost, though less impactful than structures or neutral objectives.
  + **First Tower:** A major gold swing and map control advantage.
  + **Dragons:** Provide stacking permanent buffs and the threat of a powerful Dragon Soul (even more powerful buff that is acquired after killing 4 dragons).
  + **Rift Herald:** Enables tower destruction and contributes to early momentum.
  + **Grubs:** Immense help with tower destruction, also contributes to early momentum.
  + **Baron Nashor:** Usually game-deciding, though relevant later rather than in the first ten minutes.

## **4. What Usually Decides a Match?**

1. **Draft and Composition (before the game):**  
   Success often depends on how well a team’s composition fits together. Champions with engage tools and crowd control make fights easier. Teams with a balanced damage mix (physical and magic) prevent opponents from easily buying specific items against them. Scaling champions thrive in the late game, while early-game compositions rely on snowballing.
2. **Early-Game Execution (first ten minutes):**  
   Gold and XP leads, along with early objectives, typically determine whether a team has an bigger chance for victory.
3. **Mid-to-Late Game:**  
   In closer games, vision control, objective trade-offs, and team coordination determine outcomes. Late-game champions can also overturn early disadvantages.

## **5. Prioritizing Signals of Victory**

**At draft (pre-game):**

* Lane matchups
* Champion win-rates

**At 10 minutes (early snapshot):**

* Team gold difference (most predictive)
* Team kill difference
* Team cs difference
* Team XP difference
* First tower (large gold swing and map pressure)
* Objectives secured (dragons, Herald and grubs)
* First blood (useful but less predictive)
* First tower (useful to determine early advantage)

**Simple priority order:**

1. Team gold lead
2. First tower
3. Objectives (dragons, Herald)
4. XP difference
5. First blood

## **6. Working Assumptions**

* Early-game leads are generally decisive, but exceptions occur due to throws or late-game scaling.
* Gold and first tower advantages are consistent signals across patches.
* Patches shift champion strengths and objective values, requiring adaptability.

## **7. Real-Life Applications**

* **Coaching:** Helps assess whether a draft matches a game plan, set early-game objectives, and decide strategies.
* **Players:** Reinforces why farming and early objectives are crucial, and why avoiding unnecessary early deaths matters.
* **Broadcasting and Fans:** Provides simple, explainable metrics for why one team is favored at a given time.
* **Education:** Offers a case study in prediction and strategy using clear, measurable factors.

## **8. Alternatives**

There are already existing tools that attempt to predict match outcomes in League of Legends:

1. **LoLDraftAI** - Analyzes draft phase picks and bans to estimate win chances based on team composition, synergies, and patch context. It focuses on pre-game composition but does not use early in-game data.
2. **Champ Select Coach** (Overwolf App) - Uses machine learning models to predict match outcomes after champ select, incorporating recent player performance. This is closer to a pre-game predictor but offers limited insights into early-game state.

Both provide partial solutions, but neither combines draft factors with early-game metrics in a systematic way. This leaves space for research that integrates both dimensions.

## **9. Glossary (Simplified)**

* **CS:** Minions/monsters killed.
* **Gold difference:** Net gold between teams.
* **XP/Levels:** Experience gained; unlocks abilities.
* **First Tower:** First turret destroyed, major swing.
* **Dragon/Rift Herald:** Neutral objectives with scaling value.
* **Scaling:** Champions becoming stronger later in the game.
* **Engage/CC:** Abilities to start fights and restrict enemies.
* **Snowballing:** Small leads that grow into bigger advantages over time (gold/XP => stronger fights => more objectives).

## **10. Pros and Cons of This Approach**

**Pros:**

* Builds on universal, stable fundamentals (CS, gold, XP, objectives) that remain relevant across patches
* Highlights simple, intuitive signals (gold difference, first tower, first drake, etc.) that anyone can understand
* Connects directly to practical use cases for players, coaches, and analysts, making insights actionable
* Creates a foundation for the possibility to explain momentum shifts and win probability in real time.

**Cons:**

* Oversimplification risk: raw stats can miss context like vision control, map pressure, or team coordination
* Not all advantages are visible in numbers (e.g., mental resilience, communication quality)
* Rare strategies or unusual drafts can break standard patterns and reduce predictive accuracy
* Focus on averages may overlook exceptional cases (e.g., scaling champs winning from behind, dramatic comebacks).