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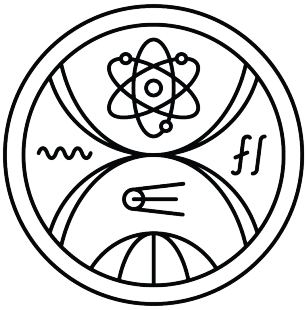

ARTIFICIAL ADVISOR IN COMPETITIVE GAMES

Master thesis

2024 Bc. Filip Barančík

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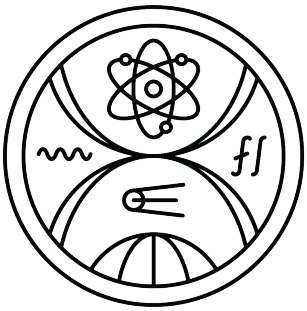

ARTIFICIAL ADVISOR IN COMPETITIVE GAMES

Master thesis

Study program:	Applied informatics
Branch of study:	Applied informatics
Department:	Department of Applied Informatics
Supervisor:	doc. RNDr. Dušan Guller, PhD.

Bratislava, 2024 Bc. Filip Barančík

Univerzita Komenského v Bratislave
Fakulta matematiky, fyziky a informatiky

ZADANIE ZÁVEREČNEJ PRÁCE

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Študijný program: aplikovaná informatika (Jednoodborové štúdium, magisterský II. st., denná forma)
Študijný odbor: informatika
Typ záverečnej práce: diplomová
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Sekundárny jazyk: slovenský

Názov: Artificial advisor in competitive games
Artificiálny poradca v kompetitívnych hrách

Anotácia: Fuzzy logika je logika, ktorá popisuje neostrosť (vágnosť) a uvažovanie, ktoré je skôr aproximatívne než exaktné. Pojem "fuzzy logika" bol zavedený v 1965, v návrhu teórie fuzzy množín L. A. Zadehom. Fuzzy logika má aplikácie v mnohých oblastiach, od teórie riadenia po umelú inteligenciu (UI).
Fuzzy expertné systémy (FES) patria k účinným UI nástrojom na emuláciu procesu bežného/expertného myslenia. Sú schopné pracovať so "soft" znalosťami (neurčitými, vágnymi, nepresnými, nekonzistentnými, neúplnými) efektívnym spôsobom. V svete kompetitívnych hier musí mať hráč na pamäti počas hry veľa premenných týkajúcich sa zloženia svojho a nepriateľského tímu z hľadiska zručností agentov hráčov alebo momentálnej ekonomiky samotnej partie, ktorá do veľkej miery mení priebeh a stratégiu. Hráč neustále čelí rozhodnutiam, ktoré môžu mať pre jeho tím prínos alebo aj stratu. Niektoré všeobecné stratégie sa ale dajú riešiť už na samotnom začiatku hry, takže hráč ide do hry s nejakým guidelinom.

Cieľ: Hlavným cieľom je vývoj artificiálneho poradcu, ktorý by hráčovi z vložených dát navrhol robiť rozhodnutia na základe techník multi-kriteriálneho fuzzy rozhodovania.

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Kľúčové slová: fuzzy rozhodovanie, fuzzy logika a inferencia, fuzzy inteligentné systémy

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Spôsob sprístupnenia elektronickej verzie práce:
bez obmedzenia

Dátum zadania: 15.12.2024

Dátum schválenia: 15.12.2024 prof. RNDr. Roman Ďurikovič, PhD.
garant študijného programu

.....
študent

.....
vedúci práce

I hereby declare that I have written this thesis by myself, only with help of referenced literature, under the careful supervision of my thesis advisor.

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Bratislava, 2024 Bc. Filip Barančík

Acknowledgement

Abstract

In Multiplayer Online Battle Arena (MOBA) games such as League of Legends, selecting the appropriate items for a champion is a crucial yet often complex decision. Players must adapt their builds in real time based on multiple factors such as enemy team composition, threat level, available gold, and game phase. Current item recommendation systems are typically static and do not sufficiently reflect the contextual nuances of live gameplay. This thesis proposes a fuzzy logic-based decision support system designed to recommend context-aware items based on dynamic in-game variables.

The system models key game-state inputs—such as enemy magic damage threat, crowd control presence, champion durability, and match timing—using fuzzy sets and linguistic rules. These inputs are then processed through a fuzzy inference engine to generate output needs such as damage, defense, magic resist, or utility. Items are evaluated against these needs using a multi-criteria scoring function, allowing for the recommendation of items that serve multiple strategic purposes simultaneously.

Keywords: fuzzy decision making, fuzzy logic and inference, fuzzy intelligent systems

Abstrakt

V hrách typu Multiplayer Online Battle Arena (MOBA), ako je napríklad League of Legends, je výber vhodných predmetov pre hrdina kľúčovým, no často zložitým rozhodnutím. Hráči musia svoje zostavy prispôsobovať v reálnom čase na základe viacerých faktorov, ako sú zloženie nepriateľského tímu, dostupné množstvo goldov a fáza hry. Súčasné systémy odporúčania predmetov sú spravidla statické a nedokážu dostatočne zohľadniť priebeh hry. Táto diplomová práca preto navrhuje rozhodovací systém založený na fuzzy logike, ktorý odporúča in game itemy reagujúc na aktuálny stav hry.

Systém modeluje kľúčové vstupné premenné herného stavu — ako je množstvo magického poškodenia zo strany nepriateľa, prítomnosť crowd control efektov, odolnosť hrdinu a fáza hry — pomocou fuzzy množín a jazykových pravidiel. Tieto vstupy sú následne spracované fuzzy inferenciou, ktorá generuje výstupné potreby ako poškodenie, obrana, magická odolnosť alebo funkcionalita. Predmety sú následne hodnotené pomocou viac-kriteriálnej hodnotiacej funkcie, čo umožňuje odporúčanie takých predmetov, ktoré plnia viacero strategických účelov súčasne.

Kľúčové slová: fuzzy rozhodovanie, fuzzy logika a inferencia, fuzzy inteligentné systémy

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Terminology

Terms

- **Nexus**
  The most important structure inside each team's base. The game is over once either team manages to destroy the nexus of the opposing team.
- **Hero**
  Player controlled unit with unique abilities, items, roles, and responsibilities.
- **Monster**
  Computer controlled unit located on the jungle side of the map. It has predefined behavior, strength, and gives player resources upon being slain. If a monster is killed, it reenters the game after a certain amount of time, depending on the type of monster.
- **Minion**
  Computer controlled unit periodically spawned in groups in nexus. It follows a path down its designated lane and attacks enemy heroes, minions, and structures. It gives resources upon being slain.
- **Item**
  Object which increases the hero's stats, making him stronger and thus more able to gather more resources, destroy enemy structures and heroes.
- **Gold**
  In game currency used by players to buy items for their heroes.

Abbreviations

- **MOBA** - Multiplayer Online Battle Arena

Motivation

In Multiplayer Online Battle Arena (MOBA) games such as League of Legends, itemization is a core strategic component that significantly impacts gameplay outcomes. Choosing the right items can mean the difference between success and failure in a given match, especially at higher levels of competitive play. However, the decision-making process is complex: it depends on dynamic variables such as enemy team composition, champion roles, in-game gold availability, and the current phase of the match.

Despite the existence of community-curated build guides and statistical recommendations, these resources are static and often do not account for the unique real-time conditions of each match. Players are frequently left to make item choices under pressure, relying on personal experience, intuition, or trial and error. This leads to suboptimal builds, particularly for new or intermediate players who may not fully grasp the nuanced impact of itemization in various game states.

Fuzzy logic offers a compelling solution to this problem. Unlike traditional binary or rule-based systems, fuzzy logic excels in environments characterized by uncertainty, partial truths, and overlapping conditions, all of which are inherent in MOBA gameplay. By modeling vague concepts such as 'high threat', 'low durability' or 'need for utility' with fuzzy variables, it becomes possible to create an intelligent and adaptable item recommendation system that better reflects the complexity of real-world decision making in game.

This thesis proposes a novel application of fuzzy logic for real-time, context-aware item recommendation in MOBA games. By evaluating multiple input criteria (such as enemy damage type, crowd control threat, champion durability, and game phase) and mapping them to a multi-criteria output (like need for damage, defense, and utility), the system aims to assist players in making smarter, situationally appropriate itemization decisions.

Chapter 1

Introduction

1.1 MOBA competitive games

In this section, we will dive into the topic of MOBA competitive games. We will introduce and explain the general idea and the goals that each team strives to achieve. We will then recall the important inner workings of MOBA games such as economy, objectives, roles, tactics, general strategy, and most importantly itemization choice. The game on which this thesis focuses is League of Legends, although it is important to mention that the general idea of this work holds for most MOBA games, and simply using a different dataset of champions, items, and stats while using the same techniques for item recommendation would work in a similar fashion.

1.1.1 Definition

Multiplayer Online Battle Arena (MOBA) games represent a distinct genre of real-time strategy games where two teams of players compete on a typically symmetrical map, conventionally divided into three main lanes. Each player controls a unique character—referred to as a champion or hero, with specific roles, abilities, and responsibilities. The main goal of each team is to destroy the main structure of the enemy team, which lies in the deepest point of the base of each team. In order to destroy this structure, now referred to as **nexus**, players must destroy all secondary structures on at least one of the three main lanes. A player might encounter a variety of entities scattered across the map.

1.1.2 In-game economy

Economy is one of the main topics discussed in relation to MOBA. Team's economy does not only dictate the style of their play, whether is aggressiveness, map control, or risk taking, but it highly affects their gameplay possibilities and probability of victory.

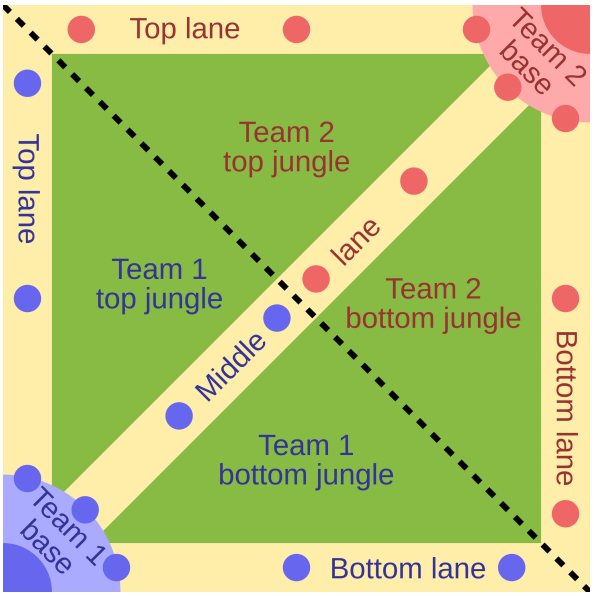

Figure 1.1: A typical layout of MOBA map

The main goal might be to destroy the enemy nexus, but in order to do so, teams have to lay strong foundation by building up their economy better than the opposing team. There are various means of gathering so-called net worth. There are two main resources in relation to economy, gold and experience. Every player controlled character (champion) can gain experience points and therefore increase his level. With each level a player is able to upgrade his champion's ability of his choosing. However, there is only a certain amount of experience points a player can amass, therefore there is maximum level which his champion can become. In this thesis we focus on in game items, which are bought for gold, so the topic of experience points only proves as an introduction into the inner workings of MOBA games.

1.1.3 Base statistics

The in game world in MOBA games is composed of base statistics. When referring to units (such as champions), a statistic measures the power of an unmodified basic attribute or capability. For example: how durable they are; how fast they are able to move; how quickly they are able to perform basic attacks; etc. A base effect (e.g. how much damage an ability deals) that increases in strength by a statistic is said to "scale with" or "scale off of" that statistic. Scaling type can either directly or indirectly influence the champion's capabilities, and often heavily correlates to the champion's design. Statistics define a champion's numerical strength at various stages of the game or a fight, but not necessarily their overall strength — nevertheless, big differences in statistics also mean a substantial difference in the way different champions and champion classes interact with each other on the battlefield, as well as influence the

game.

There are 23 types of champion statistics divided into 3 different categories: Defensive, Offensive, and Utility. In the list below, only the basic attribute of each statistic is presented. In League of Legends, modified attacks, abilities, items, and runes, may freely scale off of any and/or multiple statistics (and sometimes other effects), whether in their damage, defense, cooldown, or any other attribute.

Defensive statistics:

- Health [HP]: A champion dies when their health is reduced to zero. Some abilities and effects may scale off of your own, on your ally's, or on a target enemy's: current, bonus, missing, or maximum health.
- Health regeneration [HP5]: The amount of health a champion passively restores per 5 seconds.
- Heal and shield power: Increases the strength of healing or shielding effects on yourself or allies.
- Armor [AR]: Reduces (mitigates) the amount of physical damage taken, thus increasing a champion's effective health against physical damag
- Magic resistance [MR]: Reduces (mitigates) the amount of magic damage taken, thus increasing a champion's effective health against magic damage.
- Tenacity: Reduces the duration of most hostile crowd control effects/disables by a percentage. Stacking multiple sources of tenacity has diminishing returns. Disables cannot be reduced to under 0.5 seconds.
- Slow resist: Reduces the strength of incoming hostile slows (movement speed reductions). The reduction is a percentage of the slow's strength.

Offensive statistics:

- Attack speed [AS]: The number of basic attacks your champion is allowed to perform per second.
- Attack damage [AD]: One of the two main offensive statistics, along with Ability Power. Unmodified basic attacks deal exactly this amount of damage.
- Ability power [AP]: One of the two main offensive statistics, along with Attack Damage.
- Critical strike chance: Denotes the chance that a basic attack will critically strike. Certain abilities can also critically strike for modified damage.

- Critical strike damage: Denotes the damage dealt when a basic attack critically strikes. Abilities that can critically strike usually also benefit from critical strike damage.
- Armor penetration: When applying physical damage to an enemy, ignores a part of their armor in the damage calculations. Armor penetration can be either flat (lethality) or percentage-based. The target's armor is unchanged.
- Magic penetration: When applying magic damage to an enemy, ignores a part of their magic resistance in the damage calculations. Magic penetration can be either flat or percentage-based. The target's magic resistance is unchanged.
- Life steal: How much health a champion restores, as a percentage of the post-mitigation damage dealt by basic attacks and on-hit effects.
- Physical vamp: How much health a champion restores, as a percentage of all physical damage dealt. Physical vamp is only 33% as effective when dealing area damage or pet damage.
- Omnivamp: How much health a champion restores, as a percentage of all damage dealt. Omnivamp is only 20% as effective against non-champions.

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