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**List of Abbreviations**

OWL Web Ontology Language

SPARQL SPARQL Protocol and RDF Query Language

BCE Before the Common Era

RDF Resource Description Framework

DSL Domain-Specific Language

IMDB Internet Movie Database

# Abstract

The Semantic Web represents the future of the internet, and sports are a crucial component of that future. The primary objective of this paper is to construct an ontology encapsulating the most significant information about the boxing domain, which has not been covered in the Semantic Web thus far. The boxing ontology is developed using Protege as a development tool, OWL as a language, and SPARQL for querying. This ontology will serve as a foundation for a more comprehensive boxing ontology, enabling information retrieval about various aspects of the sport of boxing and facilitating analysis of diverse boxing data.

**Keywords** – Ontology, Knowledge Representation, Semantic Web

# 1. Introduction

Ontologies serve as a formal representation of knowledge in a specific domain, providing a machine-processable specification with well-defined meanings [1]. They can be applied to a wide range of domains, including economy, nature, hobbies, sports, and more [2, 3]. The ultimate goal of the Semantic Web is to create interconnected ontologies for all existing data, forming a comprehensive and interlinked web of information. Our focus in this paper is the sport of boxing, a domain in which the need for structured information is substantial.

The objective of this paper is to describe the process of developing a boxing ontology and to provide justification for the choice of classes, data properties, and object properties. In Section 2 (Background), we start by offering a brief history of boxing and examining existing sports ontologies. In Section 3 (Methodology), we outline the methodology employed in this research. In Section 4 (Boxing Ontology), we present the boxing ontology, including its classes, data properties, object properties, and the characteristics of the object properties. In Section 5 (Population of the domain), we demonstrate the insertion of real-world boxing information examples into the boxing ontology. In Section 6 (SPARQL queries), we have shown how we can retrieve information from our ontology by querying. Finally, in Section 8 (Conclusion), we conclude by summarizing our findings and the implications of the developed boxing ontology.

# 2. Background

## 2.1. The History of Boxing

Boxing, a combat sport with ancient origins, can be traced back to the early civilizations of Egypt, Mesopotamia, and the Mediterranean [4]. However, it was the ancient Greeks who introduced boxing as a formalized sport to the Olympic Games in 688 BCE [5]. The Romans later modified boxing by adding leather straps with metal studs, leading to the sport's temporary ban during the fall of the Roman Empire due to its brutality [6].

The modern form of boxing emerged in England during the 17th century when the first known boxing rules, the Broughton's Rules, were established in 1743 [7]. The sport continued to evolve with the introduction of the Marquess of Queensberry Rules in 1867, which mandated the use of gloves and established the basis for contemporary boxing [8].

Boxing's relevance in contemporary sports culture is significant, as it has produced numerous iconic athletes, such as Muhammad Ali, Joe Frazier, and Sugar Ray Robinson, who transcended the sport and became cultural icons [9]. Today, boxing remains popular, with major fights attracting millions of viewers and generating substantial revenues [10]. Furthermore, the sport's global appeal and the rise of prominent female boxers have contributed to its continued relevance and growth [11].

## 2.2. Existing Boxing Ontologies

After researching various online projects, we found an ontology containing several classes and properties about the boxing domain. This was found on DBpedia, which is a community-driven project that extracts structured information from Wikipedia and makes it available in a machine-readable format, using the Resource Description Framework (RDF) and ontologies [12]. In the context of boxing, DBpedia includes several classes and properties relevant to the sport.

Some of the key classes related to boxing in DBpedia include:

1. dbo:Boxer: Represents a professional or amateur boxer and includes properties like name, birth date, nationality, and weight class [13].
2. dbo:BoxingLeague: Represents a boxing organization or league, such as the World Boxing Association (WBA) or International Boxing Federation (IBF) [14].
3. dbo:BoxingMatch: Represents a boxing match or event, including properties like date, location, fighters, and outcome [15].

Additionally, DBpedia includes properties that can be used to describe boxing-specific relationships, such as:

1. dbo:weightClass: Associates a boxer with their weight class, e.g., featherweight or heavyweight [16].
2. dbo:boxingStyle: Describes a boxer's fighting style, such as orthodox or southpaw [17].

DBpedia offers a foundation for representing boxing-related information but is not sufficient and comprehensive enough. Therefore, we have developed our own boxing ontology with more classes, more object and data properties, which leads to a more meaningful representation of the boxing domain in our ontology.

# 3. Methodology

1. Determine Scope

What is the domain that the ontology will cover?

Boxing.

For what we are going to use the ontology?

To find the relation between travel and match results.

For what types of questions should the ontology provide answers?

* Get boxer’s information.
* Get boxing matches information.

Who will use and maintain the ontology?

This ontology is going to be used primarly by the students and staff of the FIEK, and it is going to be maintained by them.

2. Consider Reuse

We are not going to reuse other ontologies.

But here are two ontologies that have information about boxers

<http://ontologydesignpatterns.org/ont/boxer/boxer.owl>

<https://dbpedia.org/ontology/Boxer>

3. Enumerate Terms

Person

Boxer

Referee

Judge

BoxingMatch

BoxerEquipment

Venue

Travel

...

4. Define Taxonomy

AmatuerBoxer subClassOf Boxer

ProffesionalBoxer subClassOf Boxer

...

5. Define Properties

firstName

lastName

age

...

6. Define Facets

Cardinality

Required values

Relational characteristics

7. Define Instances

Add individuals

8. Check for Anomalies

The Data

<https://medium.com/@stephenplainte/the-sweet-data-science-a260be7bf471>

<https://github.com/FuriouStyles/BeautifulSoup_Meets_BoxRec>

# 4. The Boxing Ontology

## 4.1. Ontology Lexigon

|  |  |  |
| --- | --- | --- |
| Class Hierarchies | Object Properties | Data Properties |
| Boxing  History  Origins  Evolution  Notable Events  Famous Boxers  RulesAndRegulations  WeightClasses  RoundsAndTime  ScoringSystem  FoulsAndPenalties  RingsAndVenueRequirements  Equipment  ProtectiveGear  Gloves  HandWraps  Mouthguars  Headgear  Shoes  CornerSupplies  Techniques  Punches  Jab  Cross  Hook  Uppercut  Defense  Blocking  Slipping  BobbingAndWeaving  Clinching  Footwork  StrategyAndTactics  Participants  Boxer  Coache  Referee  Judge  Cutman  Promoter  Competitions  Amatuer  Professional  OlympicBoxing  WorldChampionships  RegionalAndNationalTitles  WeightClassTitles  OrganizationsAndAssociations  TrainingAndConditioning  SkillDevelopment  PhysicalConditioning  NutritionAndDiet  MentalPreparation  HealthAndSafety  InjuryPrevention  InjuryTreatment  ConcussionsAndBrainHealth  DopingAndDrugTesting  PopularCultureAndMedia  MoviesAndDocumentaries  BooksAndMagazines  VideoGames  SocialMediaAndInfluencers  Awards  HallOfFame  FighterOfYear  LifetimeAchievement  KnockoutOfYear | isRequiredBy  areUsedBy  hasCoach  hasPromoter  competesIn  hasWonTitle  isMemberOf  hasWinner  hasLoser  isOfficiatedBy  isJudgedBy  hasMember  regulatesCompetition  isTrainedBy  isUsedByBoxer  affects  features  isAwardedTo  isGivenBy | eventYear  regulationName  description  source  equipmentName  manufacturer  material  size  weight  technique  type  techniqueName  name  dateOfBirth  nationality  height  weight  stance  weightClass  wins  losses  knockouts  amatuerRecord  professionalRecord  competitionName  date  location  winner  loser  result  organizationName  abbreviation  headquarters  foundingYear  trainingMethodName  equipmentUsed  duration  frequency  safetyIssue  prevention  treatment  mediaTitle  mediaType  releaseYear  creator  awardName  awardYear  recipient  category  reason |

## 4.2. Restrictions, Domains and Ranges of Object Properties

**Domain Object Property Range**

Equipment isRequiredBy RulesAndRegulations

Techniques areUsedBy Boxer

Boxer hasCoach Coach

Boxer hasPromoter Promoter

Boxer competesIn Competition

Boxer hasWonTitle Award

Boxer isMemberOf OrganizationAndAssociation

Competition hasWinner Boxer

Competition hasLoser Boxer

Competition isOfficiatedBy Referee

Competition isJudgedBy Judges

OrganizationAndAssociation hasMember Boxer

OrganizationAndAssociation regulatesCompetition Competition

TrainingAndConditioning isTrainedBy Coach

TrainingAndConditioning isUsedByBoxer Boxer

HealthAndSafety affects Boxer

PopularCultureAndMedia features Boxer

Award isAwardedTo OrganizationAndAssociation

Award isGivenBy OrganizationAndAssociation

## 4.3. Validation of the Ontology

The ontology validation is done by using the Reasoner. We have used the HermiT 1.4.3.456 resoner that is provided in Protege.

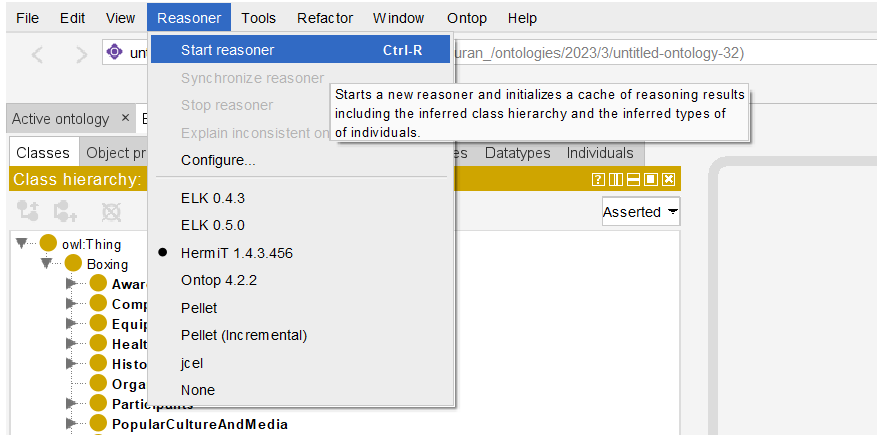


Figure 1. Resasoner VIew

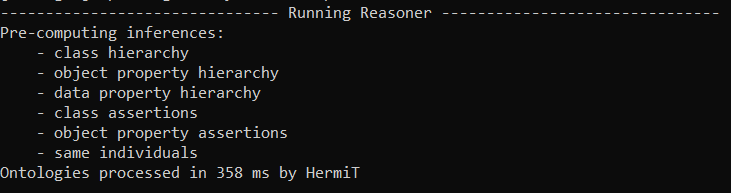


Figure 2. CMD View of Reasoner

Our ontology does not show any conflicts, after we run the HermiT reasoner.

## 4.4. Views from the Protege

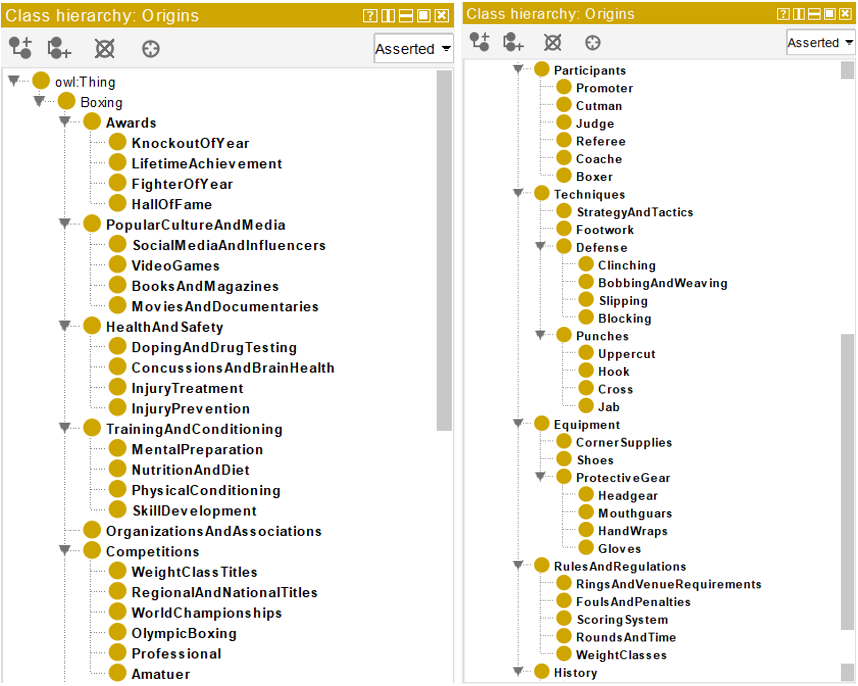


Figure 3. Class Hierarchy

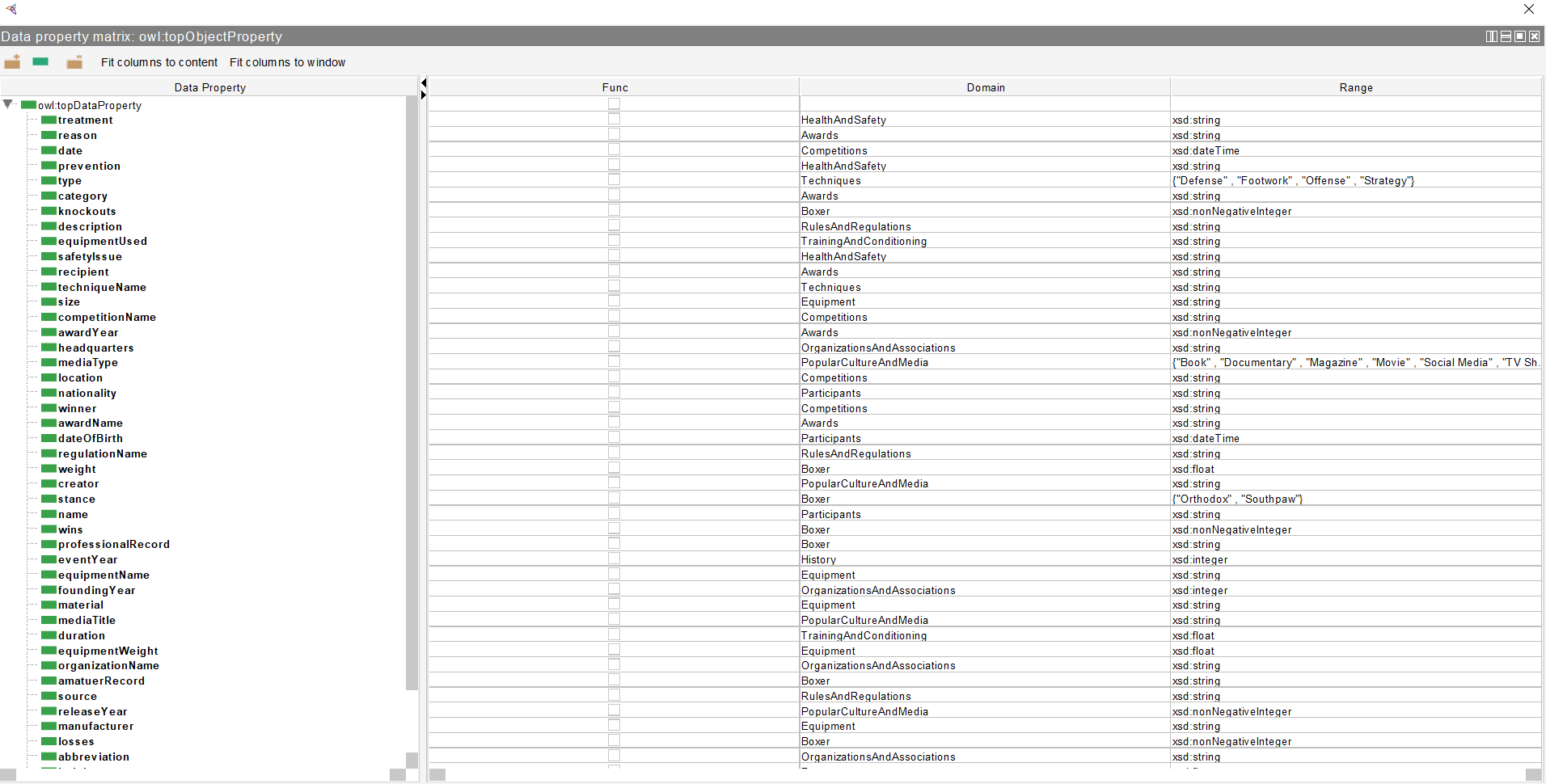


Figure 4. Data Propertie

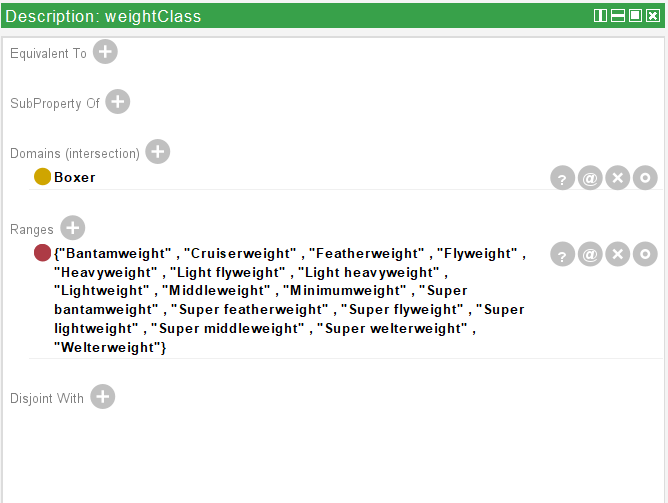


Figure 5. Example of Ranges and Domains for a data propertie

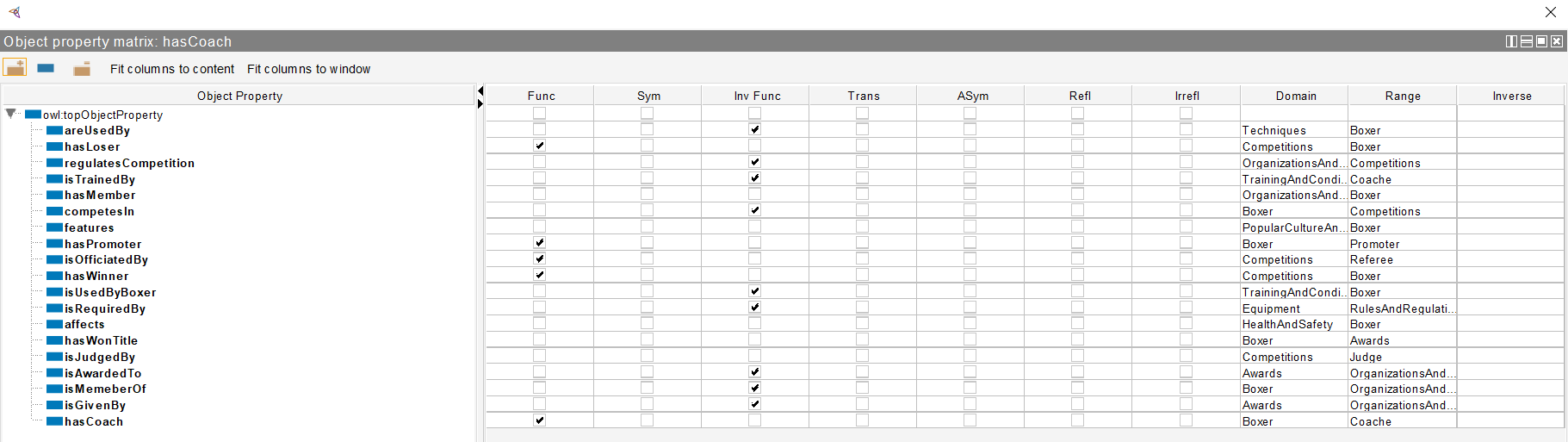


Figure 6. Object Properties

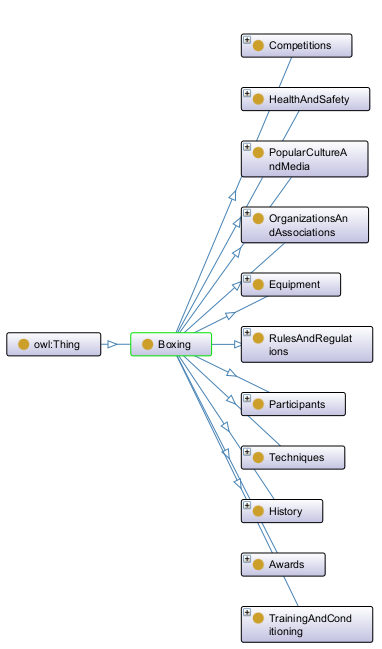


Figure 7. Onto Graph

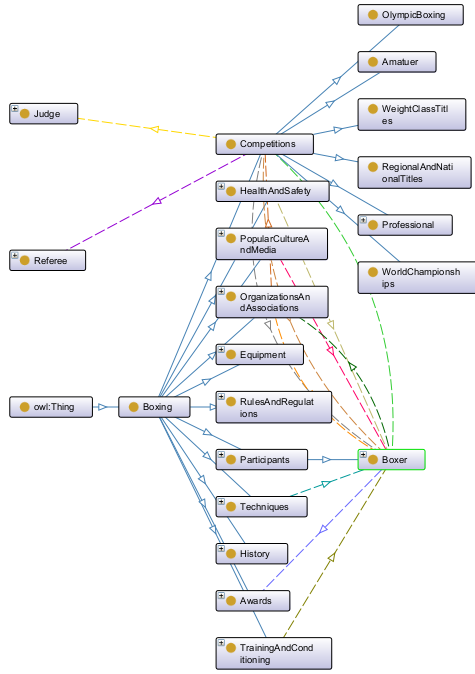


Figure 8. Onto Graph View for Boxer

# 5. Population of the domain ontology

For the population of the ontology we have used the Mapping Master DSL plugin. MappingMaster is a domain-specific language (DSL) that defines mappings from spreadsheet content to OWL ontologies. [18]

We got the data about boxers in the Boxing Matches Dataset [19] in the fighters.csv. The data that we got where not in the proper format so we created a python script convert\_from\_fighters\_to\_boxers.py to format the data as we have them in the ontology.

To get to the Cellfile in Protege we go to Tools => Create axioms from Excel Worksheet => we select the boxers.xls file. This sends us to the Cellfile window.

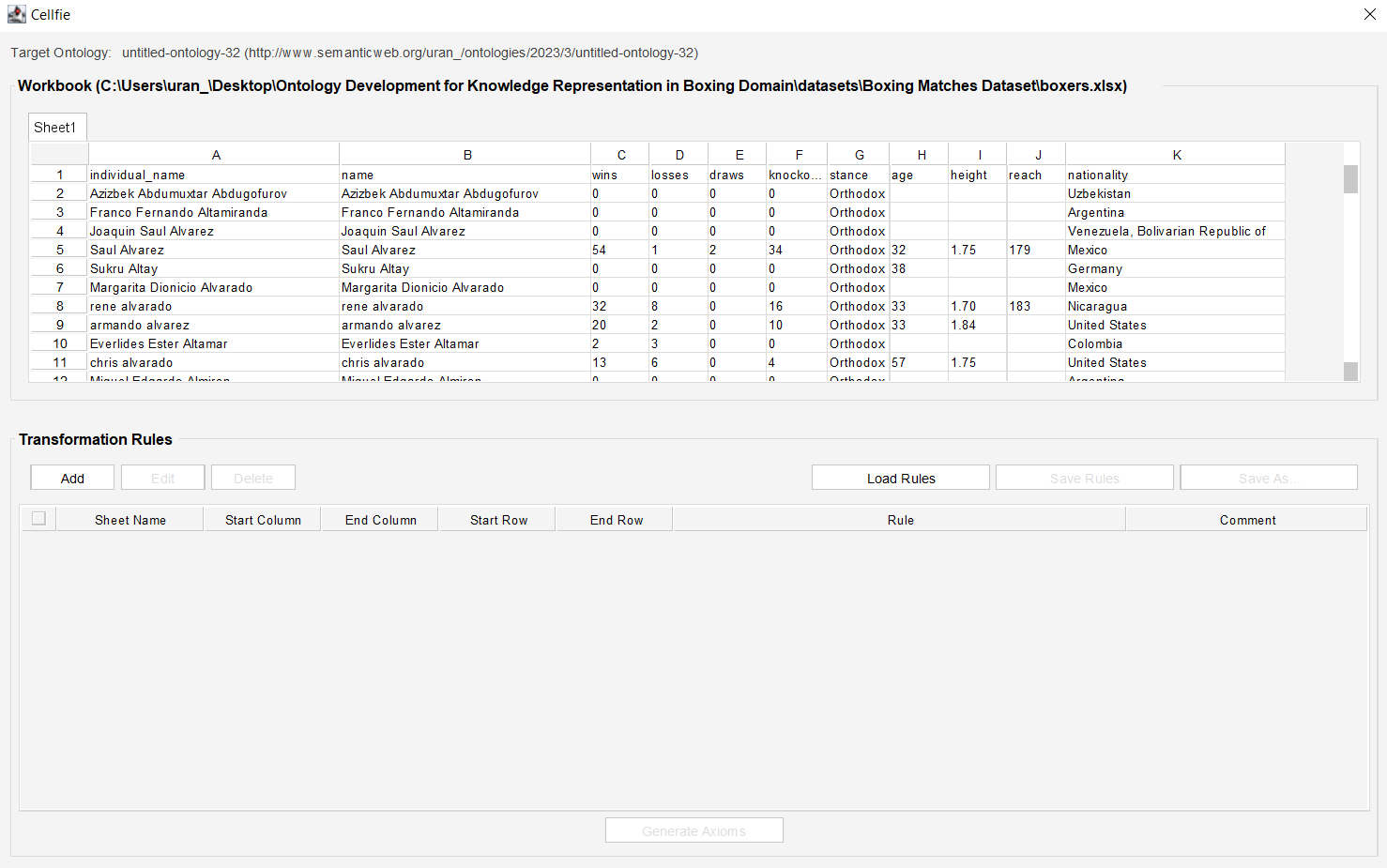


Figure 9. The view of cellfile

In the cellfile we click in add to add the transformation rules. For the boxers we add this Transformation Rule to map the boxer information from the exel sheet to the Boxer entity, and get the individuals

Individual: @A\*

Types: Boxer

Facts: name @B\*, wins @C\*, losses @D\*, draws @E\*, knockouts @F\*, stance @G\*, age @H\*, height @I\*, reach @J\*, nationality @K\*

In this way we can select the rows and columns we want. We have selected 200 rows from this dataset about the boxers, from the 2500 rows that are in total.



Figure 10. Transformator Rule Editor with the written fields

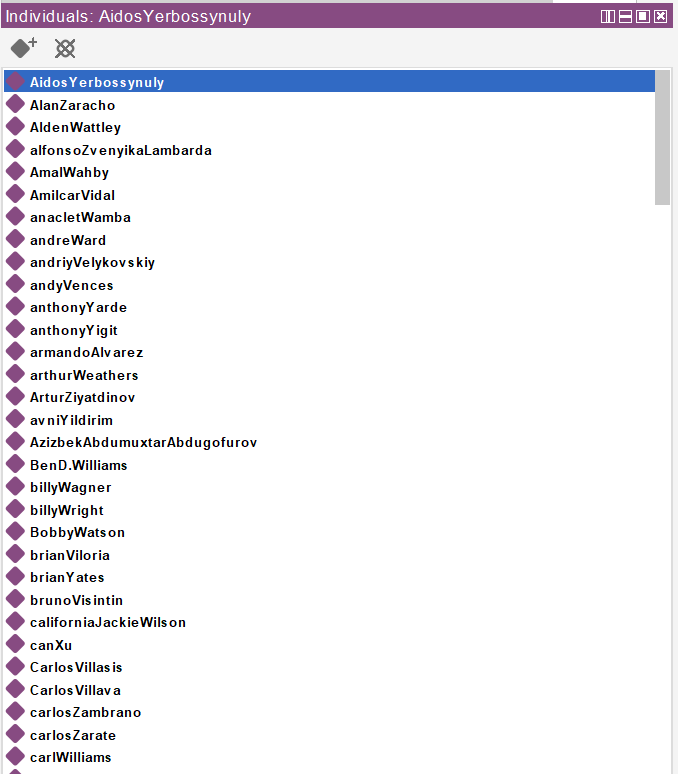


Figure 11. The added boxer individuals

For the boxing matches entity we gotten the data from the Match History of Recent Top Boxing Competitor [20] dataset.

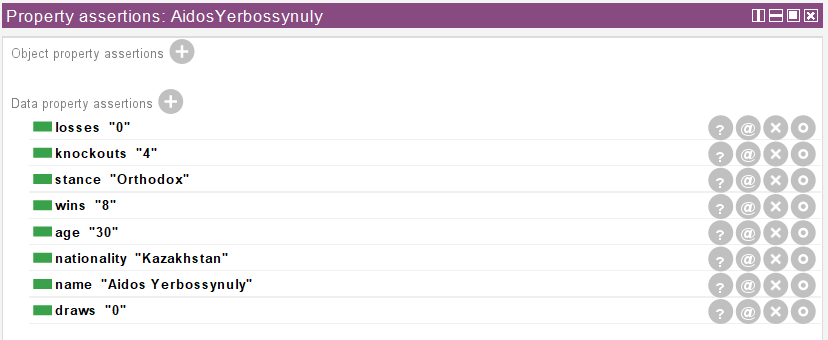


Figure 12. The added data properties for a boxer individual

Professional is a SubClass of Competitions, this entity represents the boxing matches.

Individual: @A\*

Types: Professional

Facts: date @B\*, level @C\*, location @D\*, loser @E\*, winner @F\*

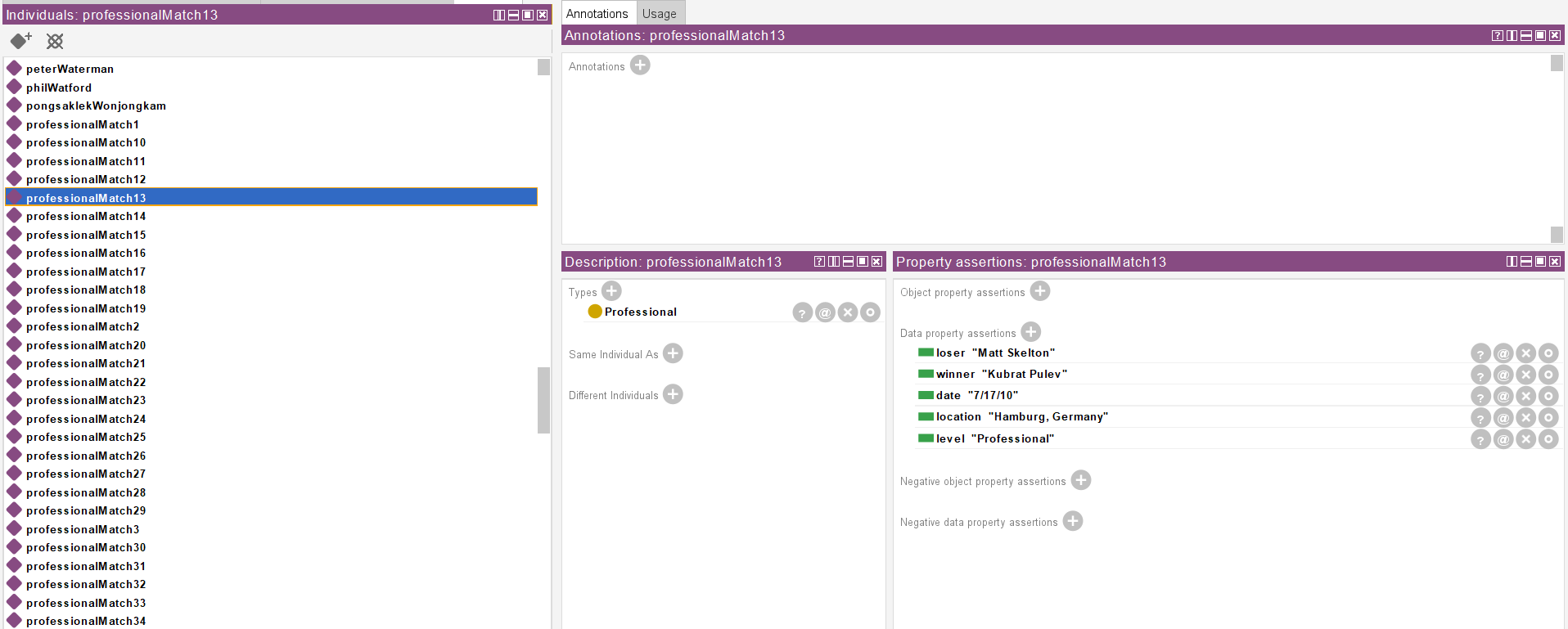


Figure 13. Professional Match Individual View

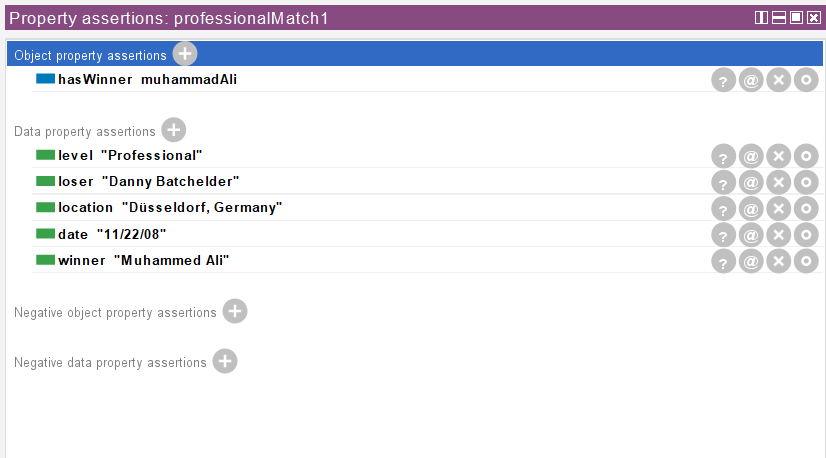


Figure 14. Object and property view of a individual of Professional Match

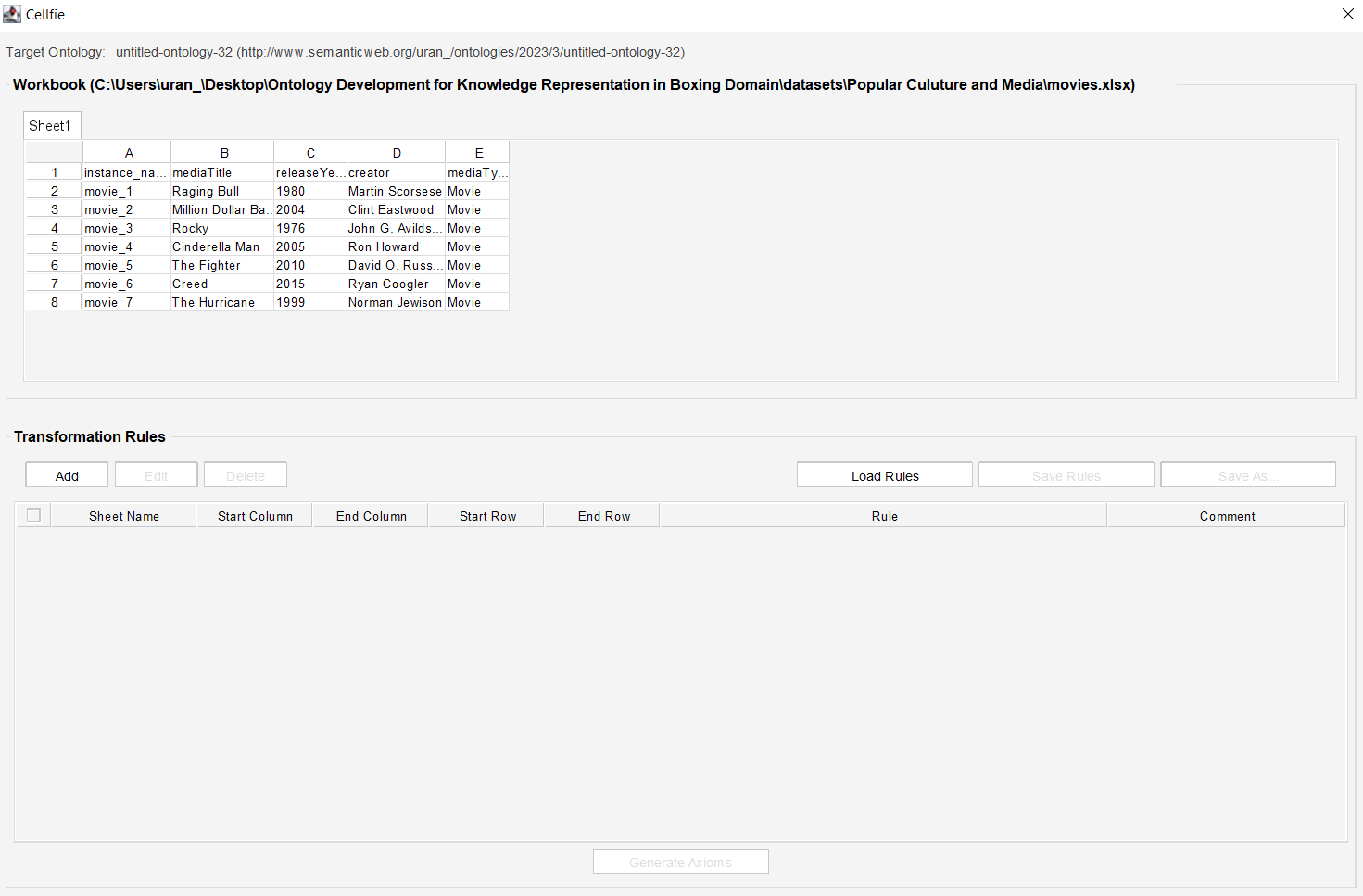


Figure 15. Movie dataset

For the movies we have gotten the data from the IMDB Movies Dataset [21]. We got a list of boxing movies, and used it to get the data from the imdb dataset. This was done with the given python script:



Figure 16. Python Script to get movie information

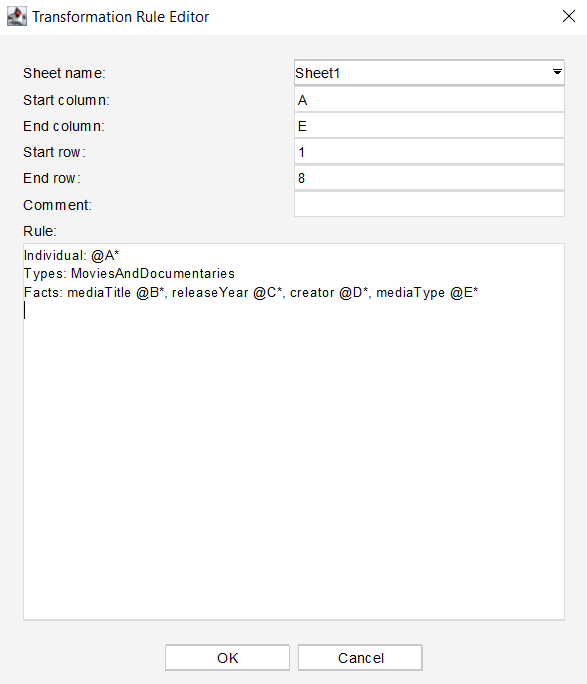


Figure 17. Transformation Rule for the Movies

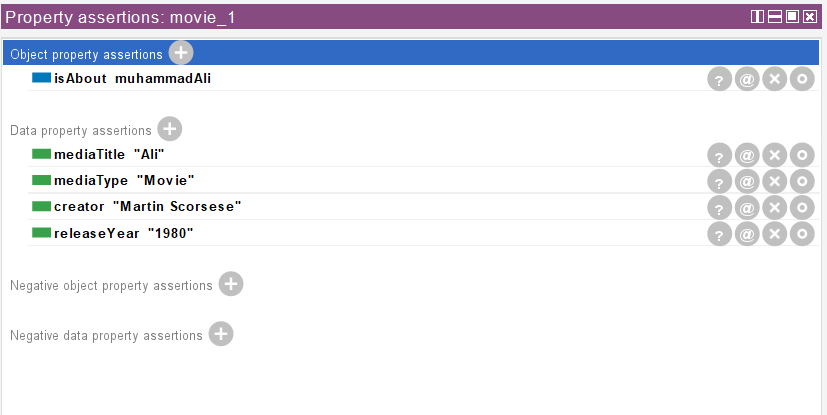


Figure 18. Data and Object Properties for the Ali Movie

# 6. SPQRL queries

# 7. SWRL rules

# 8. Conclusion

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