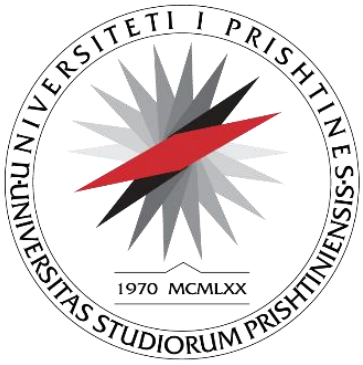
University of Prishtina “Hasan Prishtina”

Faculty of Electrical and Computer Engineering



Technical documentation of the project

Subject: Semantic Web

Project Title: Ontology Development for Knowledge Representation in Boxing Domain

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Contents

Table of Figures

List of Tables

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
SWRL	Semantic Web Rule Language
WBA	World Boxing Association
WBC	World Boxing Council
IBF	International Boxing Federation
DB	Database
CMD	Command Prompt

Abstract

The Semantic Web represents the future of the internet, encompassing various domains, including sports. In this paper, our primary objective is to construct a comprehensive ontology for the boxing domain, addressing the lack of existing coverage in the Semantic Web. By utilizing Protege as our development tool, RDF and OWL as the language of representation, and employing SPARQL for querying and SWRL rules for inference, we aim to encapsulate the most significant information about boxing.

Our ontology serves as a foundational resource, facilitating information retrieval and analysis of diverse boxing data. It encompasses a wide range of boxing-related concepts, such as boxers, boxing games, styles, techniques, equipment. By providing structured and standardized information, our ontology enhances knowledge representation in the boxing domain, benefiting various stakeholders, including trainers, athletes, and promoters.

Moreover, the integration of SPARQL enables advanced query capabilities, allowing users to extract specific boxing-related information from large datasets. Furthermore, the incorporation of SWRL rules facilitates reasoning and inference, enabling automated deduction and knowledge discovery within the boxing domain.

By developing this ontology, we contribute to the advancement of the Semantic Web and knowledge representation in the sports domain. Our work establishes a foundation for a more comprehensive boxing ontology, fostering seamless integration and interoperability with other boxing-related applications and platforms.

Keywords: Ontology, Knowledge Representation, Semantic Web, Boxing Domain, SPARQL, SWRL, Protege, OWL, RDF

1. Introduction

Ontologies serve as formal representations of knowledge in specific domains, facilitating machine-processable specifications with well-defined meanings [1]. They find applications across various domains, including sports, such as boxing [2, 3]. This paper focuses on the development of a comprehensive boxing ontology, addressing the need for structured information within this domain.
The introduction provides an overview of the paper's structure and briefly introduces each section.

Section 2 (Background) consists of two sub-sections. Sub-section 2.1 discusses the history of boxing, providing a contextual understanding of the sport. Sub-section 2.2 explores existing boxing ontologies, highlighting any gaps or limitations in the representation of boxing-specific knowledge. This examination sets the stage for the development of our dedicated boxing ontology.

Section 3 (Methodology) outlines the methodology employed in this research. It describes the approaches, tools, and frameworks utilized for developing the boxing ontology, ensuring its accuracy and relevance in capturing the nuances of boxing knowledge.

Section 4 (The Boxing Ontology) delves into the details of the developed ontology. Sub-section 4.1, titled "Ontology Lexigon," provides an in-depth exploration of the classes, relationships, and properties included in the boxing ontology. Sub-section 4.2, titled "Restrictions, Domains and Ranges of Object Properties," describes the constraints and specifications applied to the object properties within the ontology. Sub-section 4.3, titled "Validation of the Ontology," discusses the validation techniques employed to ensure the ontology's correctness and consistency. Lastly, sub-section 4.4, titled "Views from the Protege," provides insights into the visualization and management of the boxing ontology using the Protege development tool.

Section 5 (Population of the domain ontology) showcases the practical application of the boxing ontology by incorporating real-world boxing information into the ontology. This section demonstrates the ontology's capability to handle real-world data and enhances its utility for information retrieval and analysis.

Section 6 (SPARQL queries) highlights the querying capabilities of the developed ontology using SPARQL. It demonstrates how users can retrieve specific information from the ontology, enabling efficient data analysis and knowledge extraction.

Section 7 (SWRL rules) explores the integration of SWRL rules into the boxing ontology. This section explains how these rules enable automated reasoning and inference, enhancing the ontology's capabilities for knowledge discovery and advanced reasoning within the boxing domain.

Finally, Section 8 (Conclusion) summarizes the main findings, contributions, and implications of the developed boxing ontology. It provides a concise overview of the achievements and potential applications of the ontology.

2. Background

2.1. The History of Boxing

Boxing is an ancient sport with roots dating back to antiquity. It was included in the earliest Olympic Games in Greece in 688 B.C.E., and it has a rich, varied history throughout different cultures and eras [4].

In its early stages, Greek boxing (also known as Pygmachia) had fewer rules compared to the modern sport. The fighters (known as Pygmachion) used soft leather thongs to bind their hands and wrists, providing minimal protection. The Romans later adopted the sport, modifying it into a much more brutal form of entertainment, where metal-studded cesti were used and bouts often ended in death [5].

Boxing faded after the fall of the Roman Empire but reemerged in 17th century England as bare-knuckle boxing or prizefighting. These fights were quite brutal, with no rounds, no weight classes, and no prohibition on hitting a downed opponent [6].

In 1867, the Marquess of Queensberry rules were established, which made boxing less brutal and more of a regulated sport. These rules, including the mandatory use of gloves, three-minute rounds, and a ten-second count for knockdowns, are still largely in use today [7].

The 20th century saw the rise of boxing as a professional sport, with boxing champions becoming global celebrities. The sport was divided into different weight categories, and organizing bodies like the World Boxing Association (WBA), the World Boxing Council (WBC), and the International Boxing Federation (IBF) were formed to regulate these professional bouts [8].

The development and incorporation of technology in boxing, such as video replay, punch stats, and high-speed cameras, has further enhanced the understanding and knowledge representation in the boxing domain [9].

To this day, boxing remains a popular sport worldwide. Its history is characterized by evolution in technique, equipment, and regulation, making it an interesting case study for ontology development.

2.2. Existing Boxing Ontologies

In the study of knowledge representation in the boxing domain, it is essential to consider the existing ontologies. Two notable instances include a boxer-focused ontology and the broader DBpedia ontology.

The ontology found at [10] is specifically tailored for representing knowledge about boxers. It consists of classes such as Boxer, Fight, BoxingRing, WeightClass, and Organization. The individuals in the Boxer class can possess properties including hasName, hasWeight, hasHeight, hasReach, hasWinRecord, and hasLossRecord, among others. The individuals in the Fight class may have properties like hasBoxer1, hasBoxer2, hasLocation, hasWinner, and hasDate. This ontology effectively organizes data related to the boxers themselves and their interactions in the ring.

DBpedia ontology, found at [11], represents a broader and more comprehensive approach. As part of the DBpedia project, which aims to extract structured content from Wikipedia, it houses a wide range of classes and properties, some of which pertain to the boxing domain. Classes may include Athlete, BoxingMatch, BoxingStyle, and BoxingLeague. Additionally, properties such as hasBoxer, opponent, hasOutcome, hasWeightClass, and hasTitle at stake may be found within the DBpedia ontology.

2.3. Towards a More Comprehensive Boxing Ontology

While these existing ontologies provide a significant basis for understanding the sport, they fall short in providing a comprehensive ontology for the boxing domain. Both ontologies have certain limitations in terms of depth and breadth. For instance, the boxer ontology focuses primarily on boxers and their fights, while the DBpedia ontology, although broad, may not cover all aspects unique to boxing in significant detail due to its wider focus on multiple disciplines.

In our work, we aim to develop an ontology that merges the strengths of these existing models and extends beyond them. We aim to capture not only the athletes, their characteristics, and fights, but also incorporate elements such as training regimens, media data, boxing styles, and techniques, regulatory bodies, significant historical and contemporary events, and other facets that form an integral part of the boxing world. This extensive approach will enable a more comprehensive representation of knowledge in the boxing domain, providing valuable insights for a range of applications from sports management to data analytics and beyond.

3. Methodology

Our methodology for developing an ontology in the boxing domain is based on principles outlined in "A Semantic Web Primer" by Grigoris Antoniou and Frank van Harmelen [12], along with Natalya F. Noy and Deborah L. McGuinness's work, "Ontology Development 101: A Guide to Creating Your First Ontology" [13]. Following their comprehensive guidelines, we adopted a series of methodological steps, each designed to ensure the ontology's completeness, consistency, and relevance within the context of our research objectives.

Determine Scope:
Firstly, we defined the scope of our ontology, specifying that the domain to be covered is boxing, with a particular emphasis on analyzing the impact of travel on game results. This focused scope and objective guide the development process of the ontology.

Consider Reuse:
The next step involved evaluating existing ontologies for potential reuse or for deriving insights. In this context, none of the existing ontologies were deemed suitable for reuse. However, two ontologies, specifically the "Boxer" ontology available at [10] and the ontology at [11], provided valuable perspectives.

Enumerate Terms:
We then identified key terms or concepts relevant to the boxing domain and our research objective. These include, but are not limited to, Person, Boxer, Referee, Judge, BoxingMatch.

Define Taxonomy:
Following this, we established a taxonomy of classes, representing the hierarchy and relational structure within the ontology. We identified Boxer as a parent class, with AmateurBoxer and ProfessionalBoxer as its subclasses.

Define Properties:
We defined properties to encapsulate relevant attributes and relationships. For example, the Boxer class contains properties like firstName, lastName, and age.

Define Facets:
Additional facets were specified to enhance the representation of classes and properties. These facets include cardinality constraints, required values, and relational characteristics among others.

Define Instances:
The next phase of our methodology involved populating the ontology with individual instances. These instances represent real-world entities and their attributes, including specific boxing matches, boxers, venues, and travel details.

Check for Anomalies:
Finally, a comprehensive review of the ontology was conducted to identify and rectify any inconsistencies, errors, or anomalies.

By applying this structured approach, inspired by leading works in ontology development, we have created a comprehensive boxing ontology. This ontology will facilitate nuanced analysis and a deeper understanding of the influence of travel on boxing match outcomes.

4. The Boxing Ontology

4.1. Ontology Lexigon

Class Hierarchies	Object Properties	Data Properties
Awards Boxing_Awards Hall_of_Fame Boxing_Hall_of_Fame_Las_Vegas International_Boxing_Hall_of_Fame Best_Boxer_ESPY_Award Fight_of_the_Year ... Competitons Boxing_Competitions Amatuer_Competitions Olympic_Boxing Commonwealth_Games ... Professional_Competitions World_Boxing_Association World_Boxing_Super_Series ... Equipment Boxing_Equipment Corner_Supplies Shoes Protective_Gear Gloves Hand_Wraps Headgear Mouthguars Match Boxing_Match Media Books Documentaries Movies Video_Games Organizations Governing_Bodies European_Boxing_Union ... Person Athlete Boxer Amatuer_Boxer Professional_Boxer Commentator Boxing_Commentator ... Rules Boxing_Rules Styles Boxing_Styles Techniques Boxing_Techniques	commentatesBoxingMatch fightsInAmatuerBoxingCompetition fightsInProfessionalBoxingCompetition followsBoxingRules hasBoxingStyle hasBoxingTechnique hasBoxingTrainer hasPhysician hasReferee hasWonAward isAbout participatesInMatch sharesTechnique usesBoxingEquipment	age city country date division firstBoxer firstName fullName gender height lastName nationality nrOfDraws nrOfLosses nrOfWins reach residence result secondBoxer venue

Table 1. The Ontology Lexigon of the Boxing domain.

4.2. Restrictions, Domains and Ranges of Object Properties

Domain	Object Property	Range
Boxing_Commentator	commentatesBoxingMatch	Boxing_Match
Amatuer_Boxer	fightsInAmatuerBoxingCompetition	Amatuer_Competitions
Professional_Boxer	fightsInProfessionalBoxingCompetition	Professional_Competitions
Boxing_Match	followsBoxingRules	Boxing_Rules
Boxer	hasBoxingStyle	Boxer_Styles
Boxer	hasBoxingTechnique	Boxing_Techniques
Boxer	hasBoxingTrainer	Boxing_Trainer
Boxing_Match	hasPhysician	Boxing_Physician
Boxing_Match	hasReferee	Boxing_Referee
Professional_Boxer	hasWonAward	Boxing_Awards
Media	isAbout	Boxer
Boxer	participatesInMatch	Boxing_Match
Boxer	sharesTechnique	Boxer
Boxer	usesBoxingEquipment	Boxing_Equpment

Table 2. Object properties.

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.

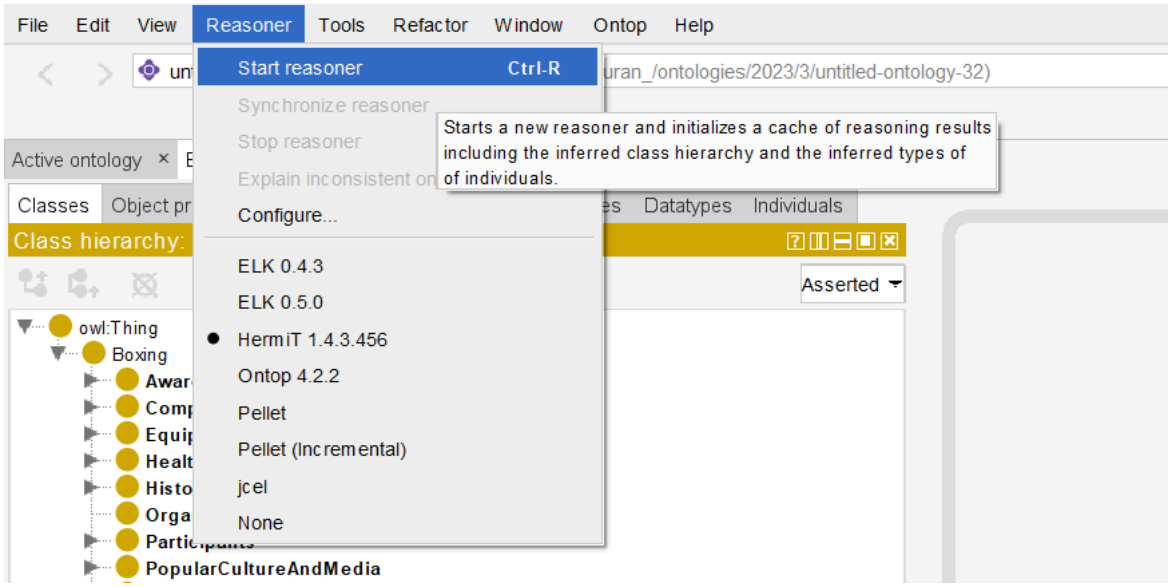


Figure 1. Resasoner VIew.

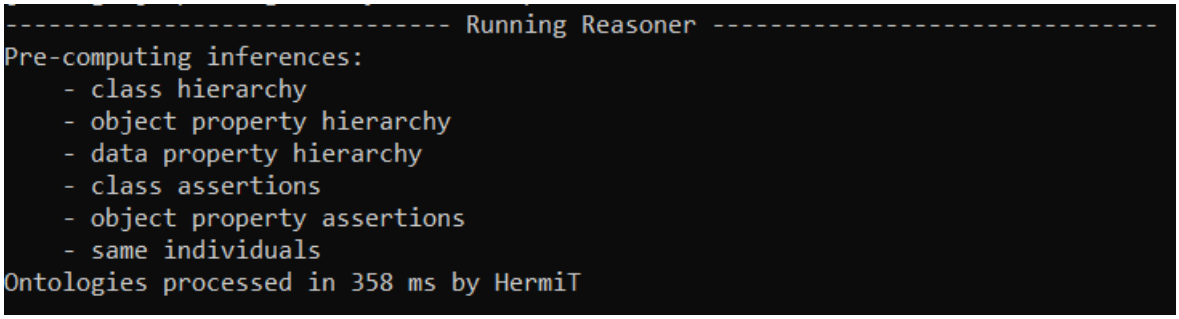


Figure 2. CMD View of Reasoner.

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

4.4. Ontology Graphs

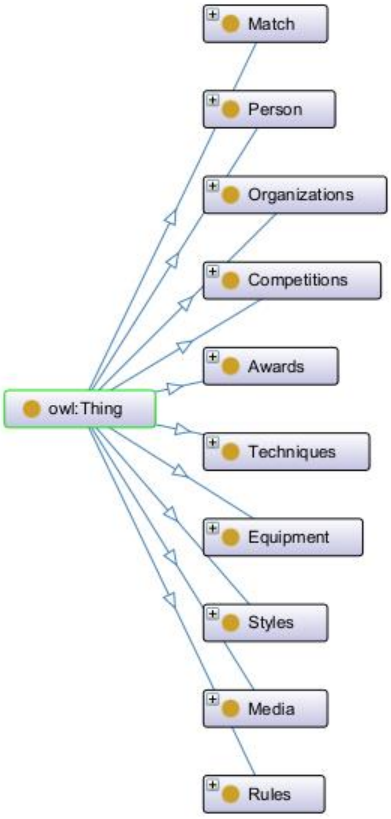


Figure 3. Onto Graph of the Boxing ontology.

5. Population of the domain ontology

5.1. Data and datasets

For boxers, boxing games and information about boxing there are some data that are formated in a dataset format. Here are some of the datasets that we found and used:

- Boxing Matches Dataset found on Kaggle [15]
- Boxing found on Kaggle [16]
- Undefeated Boxers [17]
- Boxing Data [18]
- Beautiful Soup Meets BoxRec [19]

Also we used public information about boxing that are posted in wikipedia, google and websites like BoxRec [20].

The data that are most used in our ontology are from Beautiful Soup Meets BoxRec. The datasets in Beautiful Soup Meets BoxRec are generated with web scraping by Stephen Plainte. For a comple guide in how are the datasets generated you can go to the website The Sweet Data Science by Stephen Plainte [21].

We have taken the datasets from the above databeses and websites but we have formated and cleaned them. So the boxers dataset has these attributes:

ID	Full Name	Wins	Draws	Losses	Nationality	Gender	Age	Reach	Height	Division	Residence
Boxer 1	Luis Enrique Luna	15	0	10	Mexico	male	32			light	Mexico
Boxer 2	Saul Alejandro Gonzalez Meza	4	0	5	Mexico	male	25			feather	Mexico
Boxer 3	Yonatan Perez Hernandez	4	1	12	Mexico	male	21			feather	Mexico
Boxer 4	Jonathan Gonzales	1	0	0		male				super welter	Mexico
Boxer 5	Carlos Lozano	2	0	5	Mexico	male				feather	Mexico
Boxer 6	Hector Coronado	4	0	0	United States	male			180	welter	United States
Boxer 7	Johny Gonzalez	1	0	0		male				middle	Mexico

Table 3. Boxer dataset.

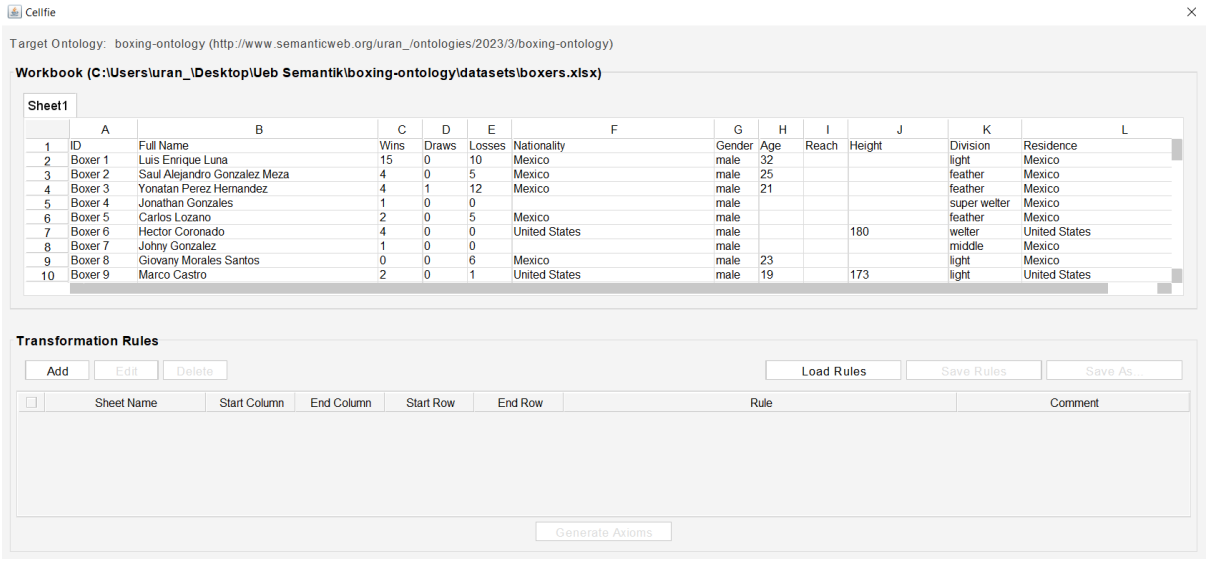
and the boxing matches dataset has these attributes:

ID	Date	Result	First Boxer	Second Boxer	Venue	City	Country
Match 1	2019-10-19T00:00:0	W	Mark Lucas	Renold Quinlan	WIN Entertainment Centre, Wollongong	Wollongong	Australia
Match 2	2002-07-15T00:00:0	W	Anthony Mundine	Lester Ellis	Vodafone Arena, Melbourne	Melbourne	Australia
Match 3	2018-11-24T00:00:0	W	Joel Camilleri	Adam Diu Abdulhamid	Town Hall, Malvern	Malvern	Australia
Match 4	2019-01-29T00:00:0	L	Alisher Khabibullaev	Mikalai Veslalou	Astoriya Riverside Club, Minsk	Minsk	Belarus
Match 5	2018-08-31T00:00:0	W	Jose Ruben Paez	Filiberto Castro	Cancha Municipal, Navojoa	Navojoa	Mexico
Match 6	2016-05-13T00:00:0	W	Luis Alfonso Bojorquez	Alberto Angel Valencia	Cancha Municipal, Navojoa	Navojoa	Mexico
Match 7	2018-03-02T00:00:0	W	Alex Millanes	Guillermo Alejandro Osorio Zarate	Cancha Municipal, Navojoa	Navojoa	Mexico

Table 4. Boxing matches dataset.

5.2. Individuals creation

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. [14]
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.



	A	B	C	D	E	F	G	H	I	J	K	L
1	ID	Full Name	Wins	Draws	Losses	Nationality	Gender	Age	Reach	Height	Division	Residence
2	Boxer 1	Luis Enrique Luna	15	0	10	Mexico	male	32			light	Mexico
3	Boxer 2	Saul Alejandro Gonzalez Meza	4	0	5	Mexico	male	25			feather	Mexico
4	Boxer 3	Yonatan Perez Hernandez	4	1	12	Mexico	male	21			feather	Mexico
5	Boxer 4	Jonathan Gonzales	1	0	0		male				super welter	Mexico
6	Boxer 5	Carlos Lozano	2	0	5	Mexico	male				feather	Mexico
7	Boxer 6	Hector Coronado	4	0	0	United States	male			180	welter	United States
8	Boxer 7	Johny Gonzalez	1	0	0		male				middle	Mexico
9	Boxer 8	Giovany Morales Santos	0	0	6	Mexico	male	23			light	Mexico
10	Boxer 9	Marco Castro	2	0	1	United States	male	19		173	light	United States

Figure 4. 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

```
{
  "Collections": [
    {
      "sheetName": "Sheet1",
      "startColumn": "A",
      "endColumn": "L",
      "startRow": "1",
      "endRow": "1000",
      "comment": "",
      "rule": "Individual: @A*\nTypes: Professional_Boxer\nFacts:
fullName @B*, nrOfWins @C*, nrOfDraws @D*, nrOfLosses @E*,
nationality @F*, gender @G*, age @H*, reach @I*, height @J*,
division @K*, residence @L*",
      "active": true
    }
  ]
}
```

In this way we can select the rows and columns we want.

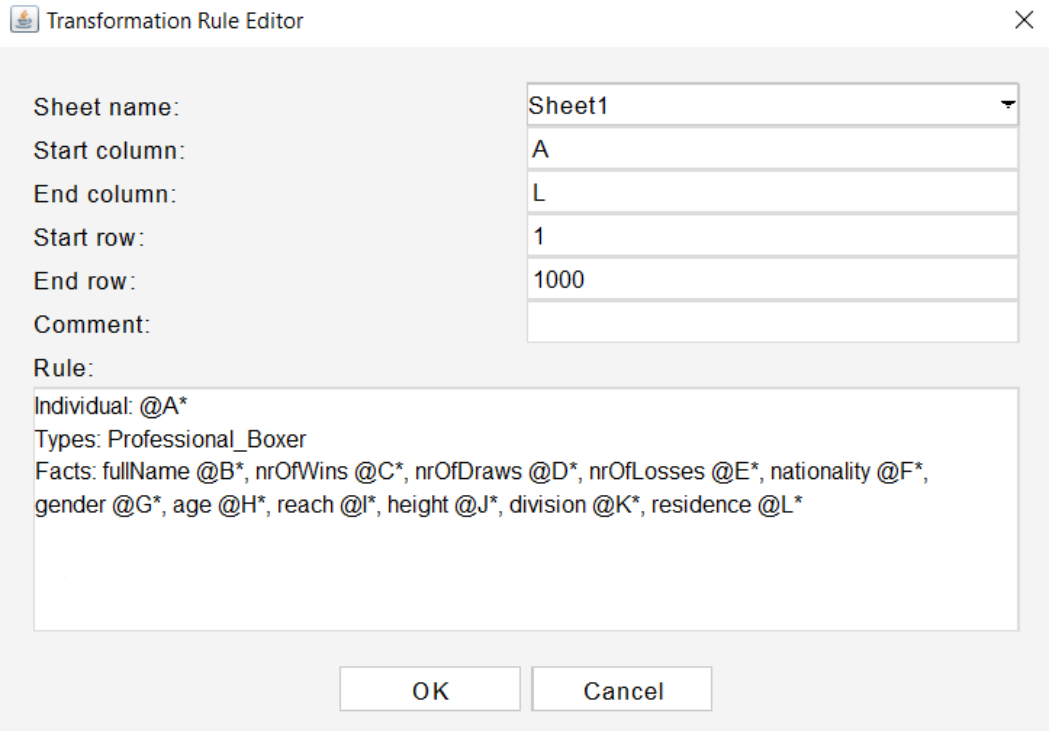


Figure 5. Transformator Rule Editor with the written fields.

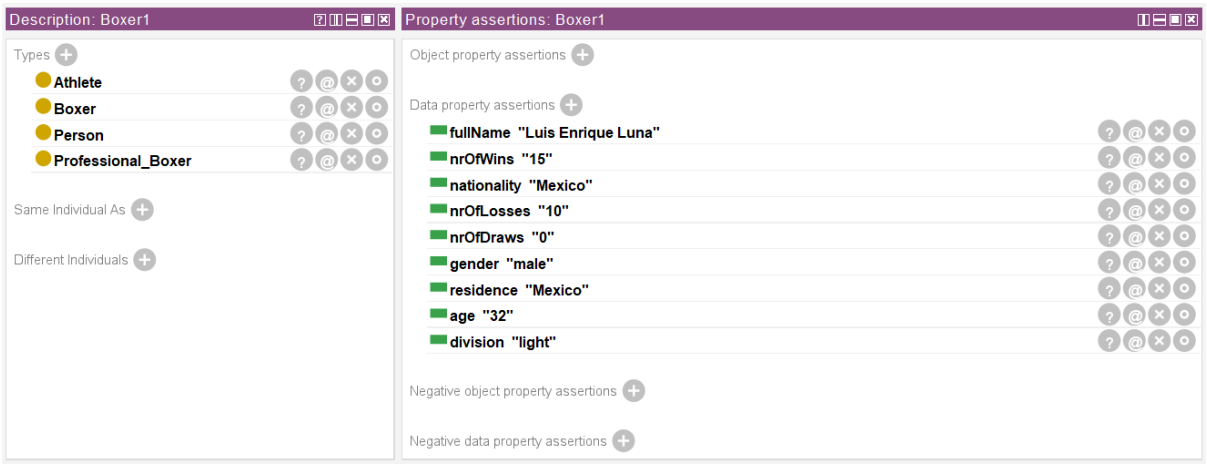


Figure 6. A added boxer individual.

6. SPARQL queries

1. Query to get the top 10 boxers based on the number of their wins:

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT ?fullName ?wins
WHERE {
    ?boxer ns:fullName ?fullName ;
           ns:nrOfWins ?wins .
}
ORDER BY DESC(?wins)
LIMIT 10
```

fullName	wins
"Full Name"@	"Wins"@
"Alexander Nedbei"@	"9"@
"Simon Madsen"@	"9"@
"Danny Kennedy"@	"9"@
"Quincy LaVallais"@	"9"@
"Alpay Yaman"@	"9"@
"Ayabonga Sonjica"@	"9"@
"Luis Martinez"@	"9"@
"Iuliano Gallo"@	"9"@
"Nuhu Azuma"@	"9"@

Figure 7. Result of the query to get 10 boxers with the most wins.

2. Query to get the bottom 10 boxers based on the number of their losses:

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT ?fullName ?losses
WHERE {
    ?boxer ns:fullName ?fullName ;
           ns:nrOfLosses ?losses .
}
ORDER BY ASC(?losses)
LIMIT 10
```

fullName	losses
"Raul Curiel"@	"0"@
"Christina Breault"@	"0"@
"Xingchuan Yi"@	"0"@
"Francisco J Mendez"@	"0"@
"George Kambosos Jnr"@	"0"@
"Erick de la Torre"@	"0"@
"Paul Brown"@	"0"@
"Hamza Omar"@	"0"@
"Marisa Takehisa"@	"0"@
"Shawn Verdin"@	"0"@

Figure 8. Result of the query to get 10 boxers with the most losses.

3. Query to group boxers based on their residence:

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-ontology#>

SELECT ?residence (GROUP_CONCAT(?fullName; separator = ", ") as ?boxers)
WHERE {
    ?boxer ns:fullName ?fullName ;
           ns:residence ?residence .
}
GROUP BY ?residence
```

residence	boxers
"Romania"@	"Viorel Simion, Alexandru Jur"
"Ghana"@	"Nuhu Azuma, David Okai, David Kotey, Victor Kuwornu, Ben Ankrah, Daniel Lartey, Justice Addy, Razak Nettey, Abdul Aziz Quartey, Ekow Wilson, Iddrisa Amadu, Ishmael Aryeetey"
"Turkey"@	"Gulsum Tatar"
"Bolivia"@	"Gabriel Averanga"
"Lithuania"@	"Arvydas Trizno, Karolis Buslys, Remigijus Ziausys, Gintare Steiblyte, Kiril Psonko, Imantas Davidaitis"
"Ecuador"@	"Alberto Bamba, Segundo Moreno, Wilson Velasco"
"Costa Rica"@	"Aldair Rojas, Jorge Mendez, Jose Manuel Perez, Wilson Silva"
"Brazil"@	"Daniel Araujo, Edson Roberto Dos Santos Borges"
"Slovenia"@	"Haris Aksalic"
"Moldova"@	"Vadim Todorov"
"Greece"@	"Georgios Poulopoulos"
"Uzbekistan"@	"Sherzodbek Mamajonov"
"Chile"@	"Juan Jimenez"
"Belgium"@	"Grischa Sarkisian"

Figure 9. Result of the query to get boxers grouped by residence.

4. Query to group boxers based on their division:

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-ontology#>

SELECT ?division (GROUP_CONCAT(?fullName; separator = ", ") as ?boxers)
WHERE {
    ?boxer ns:fullName ?fullName ;
           ns:division ?division .
}
GROUP BY ?division
```

division	boxers
"super light"@	"Mukhamed Alkhasov, Francisco J Mendez, William Valero, Rogelio Casarez, Qipng Mou, Jonathan Eduardo Ruiz, Youssef Dib, Terry Tzouramanis, Qamil Balla, Ana Laura Esteche, Yangjie Gong, Anibal Moya, Javier Alejandro Gonza
"light"@	"Daffy Dempo, Jaime Valdespino, George Kambosos Jnr, Erick de la Torre, Hector Garcia, Giovany Morales Santos, Hemdy Rahal, Muhammad Ammar, Dean Jones, Orlando Salgado, Rene Miranda, Yuma Shiromizu, Oscar Moreno, J
"bantam"@	"Rostislav O, Wataru Ikegami, Cristian Nahuel Mendez, Julias Kisarawe, Ever Caixba, Victor Efrain Sandoval, Saowaluk Nareepangsri, Satoshi Hongo, Dilan Castillo, Ryota Yamazaki, Riku Yamashita, Jasneili Hernandez, Sadayuki Y
"super welter"@	"Sasa Janjic, Aleksandar Simic, Saidi Habibu, Walter de Loera, Ferdinand Pilz, Jaime Munguia, Micah Livingston, Ahmed Issa, Mario Alberto Lozano, Ismael Gonzalez, Giorgi Ungiadze, Herve Ketonu, Shota Aikawa, Sam Eggington,
"super feather"@	"Tanawat Ketsiri, Laszlo Szoke, Luis Miguel Montano, Devis Boschiero, Hector Rodriguez, Jesus Vargas, Emilie Beaugeard, Dastanbek Imankaziev, Diuhl Olguin, Jhovany Inzunza, Carl Frampton, Milner Marcano, Kaoussou Cisse, St
"light fly"@	"Luis Medina, Melvin Manangquil, Muhsin Kizota, Anthony Desabille, Siyabonga Siyo, Juan Blas Meza, Jessica Nery Plata, Pattawee Phansawat, Lusizo Manzana, Karla Parra, Mark Vicelles, Masashi Ikeda, Christian Araneta, Alondr
"minimum"@	"Mzukisi Mthalane, Marisa Takehisa, Nadya Nakhoir, Sutthinee Bamrungpao, Ayanda Ndulani, Koya Shibata, Natsumi Agu, Somphon Banyaem, Nami Sawai, Melvin Jerusalem, Sandiso Centane, Tsukiho Suzuki, Sikho Moshani, Irene
"super fly"@	"Takayoshi Mizoguchi, Ayabulela Mbucane, Mervin Lulu, Takumi Koya, Carlos Del Real, Dipti Oswal, Steve Noblefranca, Adrian Jimenez, Maria Jose Monroy, Jesus Faro, Hernan Zamorano, Victor Zaleta, Manat Trirat, Junichi Maki,
"light heavy"@	"Zakaria Arik, Mbulelo Molose, Justin Schmit, Jalyn Anthony, Warren Roberds, Marco Antonio Periban, Wilson Santana, Pawel Stepien, Adam Bashanov, Alexander Rosales Cruz, Michael Seals, Remigiusz Woz, Jorge Liendo, Alpay
"super bantam"@	"Mirna Elizabeth La Hoz, David Murillo, Martin Gonzalez, Jesus Delgado, Yessika Loreto, Matcha Nakagawa, Ryoma Yamashiro, Giovani Rafael Mendoza, Taisei Kobayashi, Genesis Salas, Ronaldo Rangel, Leonardo Arellano, Ayabon
"cruiser"@	"Paul Brown, Shawn Verdin, Alexander Nedbe, Austin Bickerman, Clement Oppenot, Josip Jakusic, Tefik Bajrami, Johnathan Ngienia, Juan Mendez Garcia, Phillip Windemuth, Alexandru Jur, David Okai, Isaiah William Reyez, Anthon
"heavy"@	"Dragan Kokanovic, Mirko Tintor, Jesus Israel Molina, Jose Miguel Rodriguez Berno, Matthew Greer, Vicky Khan, Matthew Shefferd, Carlouse Welch, Eddie Jones, Daso Simeunovic, Jamie Black, Nuhu Azuma, Marino Goles, Nick Kis
"super middle"@	"Hamza Omar, Mada Maugo, Farouk Daku, Laszlo Toth, Erno Varga, Luis Eduardo Navarro, Mathieu Gomes, Steven New, Kanaloa Logue, Jessie Nicklow, Wangyang Chen, Gyorgy Lazar, Przemyslaw Opalach, Jose Uzcategui, Isaia
"Division"@	"Full Name"

Figure 10. Result of the query to get boxers grouped by division.

5. Query to get the boxers with the most draws:

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT ?fullName ?draws
WHERE {
    ?boxer ns:fullName ?fullName ;
           ns:nrOfDraws ?draws .
}
ORDER BY DESC(?draws)
LIMIT 10
```

fullName	draws
"Full Name"@	"Draws"@
"Terrell Jamal Woods"@	"7"@
"Rodel Tejares"@	"7"@
"Maurycy Gojko"@	"6"@
"Cosmas Cheka"@	"6"@
"Sunday Kiwale"@	"5"@
"Alejandro Santiago Barrios"@	"5"@
"Remigijus Ziausys"@	"5"@
"Alistair Warren"@	"5"@
"Said Mbelwa"@	"5"@

Figure 11. Result of the query to get 10 boxers with the most draws.

6. This query will match any firstBoxer whose name contains "Angel Fierro", regardless of case. The "i" in the third argument of regex makes the matching case-insensitive.

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT ?firstBoxer ?secondBoxer ?venue ?date ?result
WHERE {
    ?match ns:firstBoxer ?firstBoxer ;
           ns:secondBoxer ?secondBoxer ;
           ns:venue ?venue ;
           ns:date ?date ;
           ns:result ?result .
    FILTER regex(?firstBoxer, "Angel Fierro", "i")
}
```

firstBoxer	secondBoxer	venue	date	result
"Angel Fierro"@	"Francisco Javier Lopez Cha	"Big Punch Arena, Tijuana"@	"2019-04-06T00:00:00"@	"W"@
"Angel Fierro"@	"Jorge Alfredo Pitta"@	"Big Punch Arena, Tijuana"@	"2019-02-09T00:00:00"@	"W"@
"Angel Fierro"@	"Miguel Adolfo Yepez"@	"Big Punch Arena, Tijuana"@	"2018-09-22T00:00:00"@	"W"@

Figure 12. Result of the query to get the matches of Angel Fierro.

7. SPARQL query that returns the full names of boxers from the Professional_Boxer class that appear in the Boxing_Match class as a firstBoxer or secondBoxer:

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT DISTINCT ?boxerName
WHERE {
    ?boxer ns:fullName ?boxerName .

    {
        ?match ns:firstBoxer ?boxerName .
    } UNION {
        ?match ns:secondBoxer ?boxerName .
    }
}
```

boxerName
"Anthony Mundine"@
"Junior Cuadrado"@
"Joel Camilleri"@
"Vladimir Belujsky"@
"Milan Melindo"@
"Huber Dominguez"@
"Carolina Alvarez"@
"Luis Nery"@
"Francisco Javier Leon"@
"Jonathan Gonzalez Hernandez"@
"Mark Lucas"@
"Fabian Vargas Sedano"@
"Jose Alberto Beltran Ruvio"@

Figure 13. Boxers that have played in boxing matches.

8. SPARQL query that can be used to find boxers whose residence is the same as the country where the match took place. This will be determined by comparing the residence of the Professional_Boxer and the country of the Boxing_Match.

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT DISTINCT ?boxerName ?residence ?matchCountry
WHERE {
    ?boxer ns:fullName ?boxerName ;
           ns:residence ?residence .

    {
        ?match ns:firstBoxer ?boxerName ;
               ns:country ?matchCountry .
    } UNION {
        ?match ns:secondBoxer ?boxerName ;
               ns:country ?matchCountry .
    }

    FILTER(?residence = ?matchCountry)
}
```

boxerName	residence	matchCountry
"Carlos Del Real"@	"Mexico"@	"Mexico"@
"Abner Lopez"@	"Mexico"@	"Mexico"@
"Jaime Munguia"@	"Mexico"@	"Mexico"@
"Rene Miranda"@	"Mexico"@	"Mexico"@
"Yonatan Perez Hernandez"@	"Mexico"@	"Mexico"@
"Javier Alejandro Gonzalez Barrientos"@	"Mexico"@	"Mexico"@
"Luis Eduardo Navarro"@	"Mexico"@	"Mexico"@
"Carlos Lozano"@	"Mexico"@	"Mexico"@
"Juan Blas Meza"@	"Mexico"@	"Mexico"@
"Giovani Rafael Mendoza"@	"Mexico"@	"Mexico"@
"Rafael Rivera"@	"Mexico"@	"Mexico"@
"Victor Terrazas"@	"Mexico"@	"Mexico"@
"Jose Uzcategui"@	"Mexico"@	"Mexico"@
"Isaias Lucero"@	"Mexico"@	"Mexico"@

Figure 14. Result of query to get the boxers that played in they're residence country.

9. Query that finds the results of boxers that played in the country they are resident.

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT ?boxerName ?residence ?matchCountry ?result (COUNT(?match) AS
?matchCount) ?nrOfWins ?nrOfDraws ?nrOfLosses
WHERE {
    ?boxer ns:fullName ?boxerName ;
           ns:nrOfWins ?nrOfWins;
           ns:nrOfLosses ?nrOfLosses;
           ns:nrOfDraws ?nrOfDraws;
           ns:residence ?residence .
    {
        ?match ns:firstBoxer ?boxerName ;
```

```
            ns:result ?result ;
            ns:country ?matchCountry .
    }

    FILTER(?residence = ?matchCountry)
}
GROUP BY ?boxerName ?residence ?matchCountry ?result ?nrOfWins ?nrOfDraws
?nrOfLosses
```

boxerName	residence	matchCountry	result
"Valdevan Pereira"	"Brazil"	"Brazil"	"W"
"Valdevan Pereira"	"Brazil"	"Brazil"	"L"
"Abner Lopez"	"Mexico"	"Mexico"	"W"
"Abner Lopez"	"Mexico"	"Mexico"	"L"
"Abraham Cordero"	"Mexico"	"Mexico"	"D"
"Vachayan Khamon"	"Thailand"	"Thailand"	"L"
"Abraham Juarez"	"Mexico"	"Mexico"	"W"
"Abdiel Ramirez"	"Mexico"	"Mexico"	"L"
"Abdiel Ramirez"	"Mexico"	"Mexico"	"W"
"Valentin Corrales"	"Mexico"	"Mexico"	"L"
"Abhay Chand"	"Fiji"	"Fiji"	"W"
"Abhay Chand"	"Fiji"	"Fiji"	"L"
"Abhay Chand"	"Fiji"	"Fiji"	"D"
"Valentin Ivan Ortiz Hernandez"	"Mexico"	"Mexico"	"L"
"Aaron Herrera"	"Mexico"	"Mexico"	"W"
"Aaron Herrera"	"Mexico"	"Mexico"	"L"
"Valentine Hosokawa"	"Japan"	"Japan"	"L"
"Valentine Hosokawa"	"Japan"	"Japan"	"W"

Figure 15. Results of query that gives boxers that played in the country they are resident.

10. Query that finds the results of boxers that played in the country they are not resident.

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT ?boxerName ?residence ?matchCountry ?result (COUNT(?match) AS
?matchCount) ?nrOfWins ?nrOfDraws ?nrOfLosses
WHERE {
    ?boxer ns:fullName ?boxerName ;
           ns:nrOfWins ?nrOfWins;
           ns:nrOfLosses ?nrOfLosses;
           ns:nrOfDraws ?nrOfDraws;
           ns:residence ?residence .
    {
        ?match ns:firstBoxer ?boxerName ;
          ns:result ?result ;
          ns:country ?matchCountry .
    }

    FILTER(?residence != ?matchCountry)
}
GROUP BY ?boxerName ?residence ?matchCountry ?result ?nrOfWins ?nrOfDraws
?nrOfLosses
```

11. Query that shows total number of wins, losses and draws for home games.

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT (STR(COUNT(?homeWin)) AS ?totalHomeWins)
       (STR(COUNT(?homeDraw)) AS ?totalHomeDraw)
       (STR(COUNT(?homeLoss)) AS ?totalHomeLosses)
       (STR(COUNT(*)) AS ?totalMatches)
WHERE {
  ?boxer ns:fullName ?boxerName ;
         ns:nrOfWins ?nrOfWins ;
         ns:nrOfLosses ?nrOfLosses ;
         ns:nrOfDraws ?nrOfDraws ;
         ns:residence ?residence .

  {
    ?homeWin ns:firstBoxer ?boxerName ;
             ns:result "W" ;
             ns:country ?matchCountry .
  }
  UNION
  {
    ?homeLoss ns:firstBoxer ?boxerName ;
              ns:result "L" ;
              ns:country ?matchCountry .
  }
  UNION
  {
    ?homeDraw ns:firstBoxer ?boxerName ;
              ns:result "D" ;
              ns:country ?matchCountry .
  }

  FILTER(?residence = ?matchCountry)
}
```

totalHomeWins	totalHomeDraw	totalHomeLosses	totalMatches
"42"	"4"	"16"	"62"

Figure 16. Query that shows total number of wins, losses and draws for home games.

12. Query that shows total number of wins, losses and draws for away games.

```
PREFIX ns: <http://www.semanticweb.org/uran_/ontologies/2023/3/boxing-
ontology#>

SELECT (STR(COUNT(?awayWin)) AS ?totalAwayWins)
       (STR(COUNT(?awayDraw)) AS ?totalAwayDraw)
       (STR(COUNT(?awayLoss)) AS ?totalAwayLosses)
       (STR(COUNT(*)) AS ?totalMatches)
WHERE {
  ?boxer ns:fullName ?boxerName ;
         ns:nrOfWins ?nrOfWins ;
         ns:nrOfLosses ?nrOfLosses ;
         ns:nrOfDraws ?nrOfDraws ;
```

```
        ns:residence ?residence .

  {
    ?awayWin ns:firstBoxer ?boxerName ;
             ns:result "W" ;
             ns:country ?matchCountry .
  }
  UNION
  {
    ?awayLoss ns:firstBoxer ?boxerName ;
              ns:result "L" ;
              ns:country ?matchCountry .
  }
  UNION
  {
    ?awayDraw ns:firstBoxer ?boxerName ;
              ns:result "D" ;
              ns:country ?matchCountry .
  }

  FILTER(?residence != ?matchCountry)
}
```

totalAwayWins	totalAwayDraw	totalAwayLosses	totalMatches
"5"	"2"	"22"	"29"

Figure 17. Query that shows total number of wins, losses and draws for away games.

	Number of Wins	Number of Draws	Number of Losses	Total Matches
Home Matches	42	4	16	62
Away Matches	5	2	22	29
Total Matches	47	6	38	91

Table 5. The difference of results for home and away games.

	Number of Wins	Number of Draws	Number of Losses
Home Matches	67.74%	6.45%	25.81%
Away Matches	17.24%	6.9%	75.86%
Total Matches	46.15%	4.4%	49.45%

Table 6. The difference of results for home and away games in percentages.

7. SWRL rules

1. Rule that counts the number of boxers

```
Boxer(?s) -> sqwrl:count(?s)
```

2. Rule that selects the boxers

```
Boxer(?s) -> sqwrl:select(?s)
```

3. Rule that finds the lowest age

```
autogen1:Professional_Boxer(?x) ^ autogen1:age(?x, ?y) ->
sqwrl:min(?y)
```

4. Rule that selects boxer with age greater than 30

```
autogen1:Boxer(?s) ^ autogen1:age(?s, ?a) ^ swrlb:greaterThan(?a,
30) -> sqwrl:select(?s, ?a)
```

5. Sort matches by date

```
Boxing_Match(?x) ^ date(?x,?y) -> sqwrl:select(?x,?y) ^
sqwrl:orderBy(?y)
```

6. If a boxer has at least a win that he is a professional boxer

```
autogen0:Boxer(?b) ^ autogen0:nrOfWins(?b, ?a) ^
swrlb:greaterThan(?a, 0) -> autogen0:Professional_Boxer(?b)
```

8. Conclusion

In this paper, we presented the development of an ontology for knowledge representation in the boxing domain. The purpose of the ontology was to provide a comprehensive and structured framework for organizing and capturing information related to boxing.

We began by providing an introduction to the topic, followed by a background section that explored the history of boxing and existing boxing ontologies. It was identified that there was a need for a more comprehensive ontology in the domain.

The methodology section outlined the approach taken in developing the ontology. We then presented the Boxing Ontology, which consisted of class hierarchies, object properties, and data properties. The Ontology Lexicon provided a clear structure for organizing various concepts and entities related to boxing, including awards, competitions, equipment, matches, media, organizations, persons, rules, styles, and techniques.

To populate the domain ontology, data and datasets were utilized, and individuals were created based on the defined classes and properties.

Furthermore, we implemented SPARQL queries to query the ontology and retrieve relevant information. Additionally, we employed SWRL rules to infer new knowledge based on the existing ontology data.

In conclusion, the development of the ontology provided a valuable resource for knowledge representation in the boxing domain. The ontology allowed for organized and structured information retrieval and inference capabilities. The correlation between wins, losses, and draws in home and away matches was also examined, revealing interesting insights into the performance of boxers in different settings. The results showed that home matches had a higher percentage of wins compared to away matches, which had a higher percentage of losses.

Overall, the developed ontology and the associated SPARQL queries and SWRL rules contribute to a better understanding and utilization of boxing-related information. Future work may involve further refinement and expansion of the ontology to encompass additional aspects of the boxing domain and to support more advanced reasoning capabilities.

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