

Car Configuration Ontology

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Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Competency Questions

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

We have compiled the following list of Competency Questions:

- Is item X compatible with model Y?
- Is item X compatible only with model Y?
- What models are compatible with item X?
- Is item X1 compatible with item X2?
- Is item X standard or optional?
- Is model Y an electric vehicle?
- What interior trim options are there for model Y?
- Does item X1 include item X2?
- Is item X an interior or exterior item?
- Is model Y available with large wheels?
- Is a glass roof available for model Y?

Use Cases

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

- Finding out which configuration items are compatible with the desired vehicle
- Checking the compatibility configuration items between themselves

Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Engine Options

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

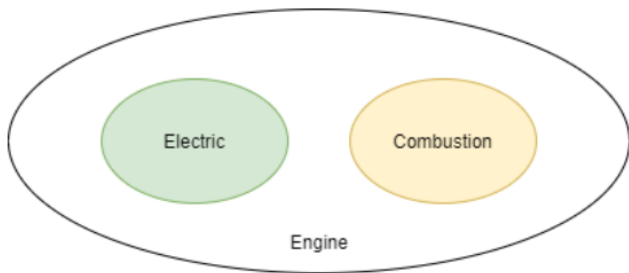
Rules

Ontology
Design
Patterns

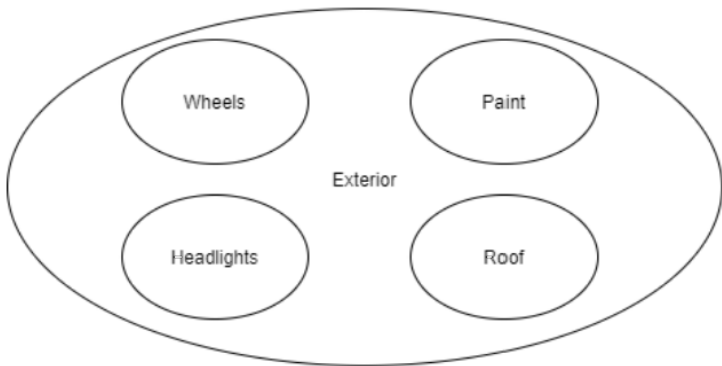
Racer Java
API

FuzzyDL

Queries



Exterior Options



Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Interior Options

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

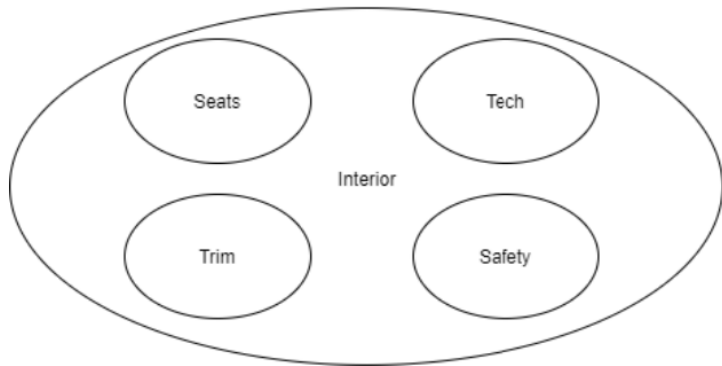
Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries



Taxonomy

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

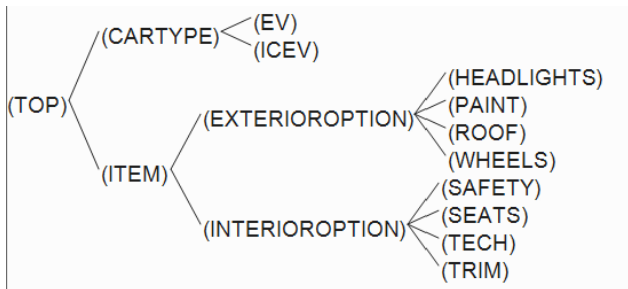


Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Exterior Items

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Instances

; — WHEELS —

(instance Wheels19 Wheels)

(instance Wheels20 Wheels)

(instance Wheels21 Wheels)

; — PAINT —

(instance MetallicPaint Paint)

(instance PearlescentPaint Paint)

; — HEADLIGHTS —

(instance LEDLights Headlights)

(instance MatrixLEDLights Headlights)

; — ROOF —

(instance CarbonRoof Roof)

(instance GlassRoof Roof)

(instance PanoramicRoof Roof)

Interior Items

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Instances

; — SEATS —

(instance HeatedSeats Seats)

(instance HeatedSeats (equal isOptional 1))

(instance HeatedSeats (equal hasPrice 500))

(instance RegularSeats Seats)

(instance RegularSeats (equal isOptional 0))

(instance RegularSeats (equal hasPrice 0))

(instance SportSeats Seats)

; — TECH —

(instance ElectricBoot Tech)

(instance Camera Tech)

(instance ACC Tech)

(instance FullTechPack Tech)

(instance StarterTechPack Tech)

Interior Items

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Instances

; — TRIM —

(instance MetalTrim Trim)

(instance WoodTrim Trim)

(instance RegularLeather Trim)

(instance NappaLeather Trim)

; — SAFETY —

(instance BlindSpotMonitor Safety)

(instance BlindSpotMonitor (equal isOptional 1))

(instance BlindSpotMonitor (equal hasPrice 300))

(instance FullSafetySystem Safety)

(instance FullSafetySystem (equal isOptional 1))

(instance FullSafetySystem (equal hasPrice 900))

(instance ParkingSensors Safety)

(instance ParkingAssistant Safety)

Taycan Vehicle

Car Configuration Ontology

Andrei Rusu,
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Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

```
(DESCRIBE-INDIVIDUAL1 TAYCAN DEFAULT)
(TAYCAN
 :ASSERTIONS
 (( (TAYCAN EV) )
 :ROLE-FILLERS
 (( (ISCOMPATIBLECARITEM
 (WOODTRIM
 LEDLIGHTS
 GLASSROOF
 PARKINGASSISTANT
 BLINDSPOTMONITOR
 PARKINGSENSORS
 STARTERTECHPACK
 CAMERA
 ACC
 ELECTRICBOOT
 HEATEDSEATS
 REGULARSEATS
 PEARLESCENTPAINT
 WHEELS21
 WHEELS20
 PANORAMICROOF
 FULLTECHPACK
 MATRIXLEDLIGHTS
 NAPPALEATHER
 FULLSAFETYSYSTEM
 SPORTSEATS) ) )
 :TOLD-ATTRIBUTE-FILLERS
 NIL
 :TOLD-DATATYPE-FILLERS
 NIL
 :ANNOTATION-DATATYPE-PROPERTY-FILLERS
 NIL
 :ANNOTATION-PROPERTY-FILLERS
 NIL
 :DIRECT-TYPES
 :TO-BE-COMPUTED)
```

Macan Vehicle

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

```
(DESCRIBE-INDIVIDUAL1 MACAN DEFAULT)
(MACAN
:ASSERTIONS
 ( (MACAN ICEV) )
:ROLE-FILLERS
 ( (ISCOMPATIBLECARITEM
  (REGULARSEATS
   PARKINGSSENSORS
   METALTRIM
   ELECTRICBOOT
   METALLICPAINT
   WHEELS20
   WHEELS19
   CARBONROOF
   STARTERTECHPACK
   LEDLIGHTS
   REGULARLEATHER
   PARKINGASSISTANT
   HEATEDSEATS) ) )
:TOLD-ATTRIBUTE-FILLERS
NIL
:TOLD-DATATYPE-FILLERS
NIL
:ANNOTATION-DATATYPE-PROPERTY-FILLERS
NIL
:ANNOTATION-PROPERTY-FILLERS
NIL
:DIRECT-TYPES
:TO-BE-COMPUTED)
```


Packs & Inclusions

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

; Seats packs

(related RegularSeats HeatedSeats isIncluded)

(related HeatedSeats SportSeats isIncluded)

; Light packs

(related LEDLights MatrixLEDLights isIncluded)

; Roof packs

(related GlassRoof PanoramicRoof isIncluded)

; Tech packs

(related ElectricBoot StarterTechPack isIncluded)

(related StarterTechPack FullTechPack isIncluded)

(related Camera FullTechPack isIncluded)

(related ACC FullTechPack isIncluded)

Packs & Inclusions

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

; Trim packs
(related MetalTrim RegularLeather isIncluded)
(related WoodTrim NappaLeather isIncluded)
; Safety Packs
(related ParkingSensors ParkingAssistant isIncluded)
(related ParkingAssistant FullSafetySystem isIncluded)
(related BlindSpotMonitor FullSafetySystem isIncluded)

Visual Representation

Car
Configuration
Ontology

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Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

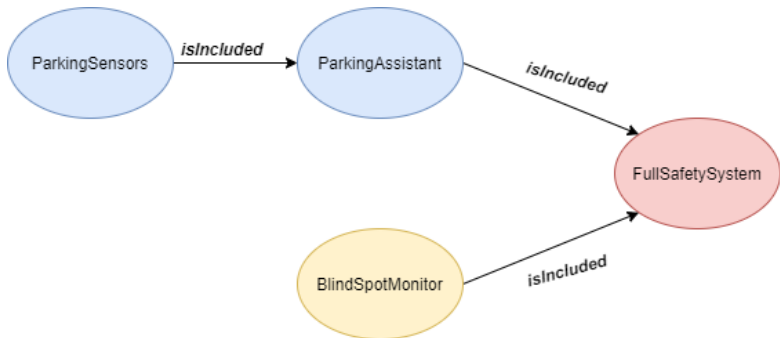


Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Roles

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

- isCompatibleCarlItem
- isCompatibleItemItem
- isIncluded

Role Definitions

Car
Configuration
Ontology

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Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

isCompatibleCarItem :domain CarType :range Item
isCompatibleItemItem :domain Item :range Item :symmetric t
isIncluded :domain Item :range Item :asymmetric t

Domain Attributes

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

(define-concrete-domain-attribute hasPrice :type integer)
(define-concrete-domain-attribute isOptional :type integer)

Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Inclusion Compatibility

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

```
(define-rule (?car ?item2 isCompatibleCarItem)
  (and (?car CarType) (?item1 Item) (?item2 Item) (not
    (same-as ?item1 ?item2))
  (?car ?item1 isCompatibleCarItem) (?item2 ?item1
    isIncluded)))
```

Explanation

If a car is compatible with an item that includes another item, the car is also compatible with that other item.

Item Compatibility

Car
Configuration
Ontology

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Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

```
(define-rule (?item1 ?item3 isIncluded)
  (and (?item1 Item) (?item2 Item) (?item3 Item) (not (same-as
    ?item1 ?item2)) (not (same-as ?item2 ?item3)) (not (same-as
    ?item1 ?item3))
    (?item1 ?item2 isIncluded) (?item2 ?item3 isIncluded))))
```

Explanation

If item1 is included in item2 and item2 is included in item3, item1 is included in item3 (transitivity).

Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Set

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Used to model sets of elements that are all unique.

Examples

All item categories (both interior and exterior)

ViewInheritance

Car
Configuration
Ontology

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Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

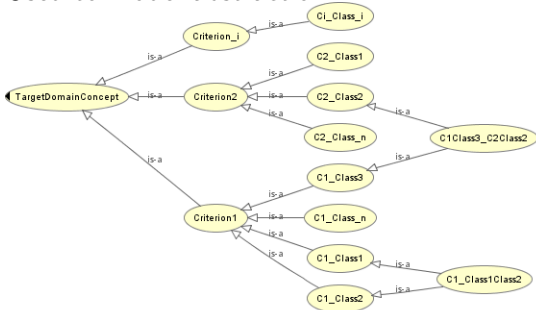
Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Used to model abstraction.

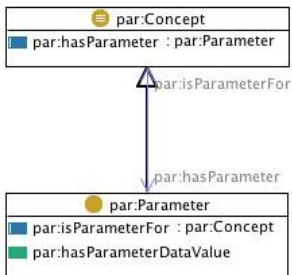


Examples

Only instances of sub-categories, not abstract categories
(Wheels not ExteriorItem)

Parameter

Used to model characteristics of concepts.



Examples

Price and optionality of components (hasPrice & isOptional).

PartOf

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

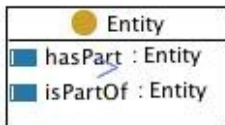
Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Used to model entities and their component parts.



Examples

Equipment packs that are made up of other components.

Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

JRacer

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

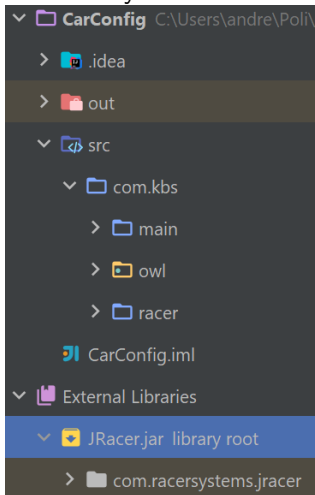
Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

The library used to communicate with Racer from Java.



Establishing a connection

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

The method of connecting the Racer backend to the Java application

```
String ip = "127.0.0.1";  
int port = 8088;  
RacerClient racer = new RacerClient(ip, port);  
try {  
    racer.openConnection();  
    System.out.println(racer.sendRaw( command: "(racer-read-file " + input + ")"));  
}
```

Java Code

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Performs the actual work

```
// obtain all individuals
String answer = racer.sendRaw(command: "(concept-instances +top+)");
String[] result = answer.replaceAll(regex: "[\n]", replacement: "").split(regex: "\n");

// if their categories are disjoint, they are compatible
for (String item1 : result) {
    for (String item2 : result) {
        if (!item1.equals(item2) &&
            !item1.equals("MACAN") &&
            !item1.equals("TAYCAN") &&
            !item2.equals("MACAN") &&
            !item2.equals("TAYCAN")) {
            boolean disjoint = racer.returnBoolean(racer.sendRaw(command: "(evaluate (concept-disjoint-p (car (car (most-specific-instantiators "
                + item1 + " (current-abox)))) (car (car (most-specific-instantiators "
                + item2 + " (current-abox)))) (current-tbox))))"));
            if (disjoint) {
                racer.sendRaw(command: "(related " + item1 + " " + item2 + " ISCOMPATIBLEITEMITEM)");
            }
        }
    }
}
```

Explanation

Infers item-to-item compatibility based on their categories.

Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Steps

Car Configuration Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

- We wanted to express how expensive a component is
- We created the file "FuzzyCar.txt" which contains the concepts, instances and interrogations in Fuzzy DL.
- We downloaded from <http://www.umbertostraccia.it/cs/software/fuzzyDL/fuzzyDL>
- We accessed the folder in which the .jar and "FuzzyCar.txt" reside
- We opened the cmd terminal by typing cmd into the file path area (Windows) and ran the following command:
java -jar FuzzyDL.jar FuzzyCar.txt

Results

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

```
E:\An 4\Sem II\KBS\Proj\FuzzyDLWindows\FuzzyDL>java -jar FuzzyDL.jar FuzzyCar.txt
Is P1 instance of ExpensivePart ? >= 0.0
Is P2 instance of ExpensivePart ? >= 0.416667
```

Code

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

```
(define-modifier very linear-modifier(0.8))  
(define-fuzzy-concept Part1PriceRange crisp(0,10000,80,1500))  
(define-fuzzy-concept Part2PriceRange  
  crisp(0,10000,6000,10000))  
(define-fuzzy-concept Expensive  
  right-shoulder(0,10000,4000,10000))  
(define-concept ExpensivePart (and Part (some Price (very  
  Expensive))))  
(instance P1 (and Part (some Price Part1PriceRange)) 1)  
(instance P2 (and Part (some Price Part2PriceRange)) 1)  
(min-instance? P1 ExpensivePart)  
(min-instance? P2 ExpensivePart)
```

Table of Contents

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

1 CQs and Use Cases

2 TBox

3 ABox

4 Roles

5 Rules

6 Ontology Design Patterns

7 Racer Java API

8 FuzzyDL

9 Queries

Racer Queries

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Examples

(related-individuals isCompatibleCarItem)

(related-individuals isCompatibleItemItem)

(related-individuals isIncluded)

(individual-fillers Taycan isCompatibleCarItem)

(concept-disjoint? Wheels Tech)

(individuals-related? ParkingSensors FullSafetySystem
isIncluded)

(evaluate (λ (retrieve-individual-told-attribute-value
'HeatedSeats 'hasPrice (current-abox)))

Racer Queries

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Examples

```
(retrieve-individual-told-attribute-value 'RegularSeats 'hasPrice  
(current-abox))))
```

```
(individuals-related? Taycan BlindSpotMonitor  
isCompatibleCarlItem)
```

```
(individuals-related? Taycan ParkingSensors  
isCompatibleCarlItem)
```

```
(individuals-related? BlindSpotMonitor Wheels19  
isCompatibleItemItem)
```

```
(retrieve-individual-told-attribute-value 'HeatedSeats  
'isOptional (current-abox))
```

NRQL Queries

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Examples

```
(get-nrql-version)
(enable-nrql-warnings)
(defquery is-interior (?x) (or (?x Seats) (?x Safety) (?x Tech)
(?x Trim)))
(defquery is-included (?x ?y) (?x ?y isIncluded))
; all interior items (retrieve (?x) (?x is-interior))
; items included in other items (retrieve (?x ?y) (?x ?y
is-included))
```

NRQL Queries

Car
Configuration
Ontology

Andrei Rusu,
Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Examples

; interior trim for Taycan

```
(defquery trim-options (?car ?trim) (and (?car CarType) (?trim Trim) (?car ?trim isCompatibleCarItem)))
```

```
(retrieve (?trim) (Taycan ?trim trim-options))
```

; models compatible with an item

```
(defquery compat-cars (?car ?item) (and (?car CarType) (?item Item) (?car ?item isCompatibleCarItem)))
```

```
(retrieve (?car) (?car SportSeats compat-cars))
```

Racer Query Results

Car
Configuration
Ontology

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Bogdan
Dragoteanu

CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

Racer Message (STDOUT):(ABOX-CONSISTENT?) $\rightarrow T$
(TBOX-CYCLIC?) $\rightarrow NIL$
(TBOX-COHERENT?) $\rightarrow T$
(EVALUATE (LENGTH (ALL-INDIVIDUALS))) $\rightarrow 28$
(EVALUATE (LENGTH (ALL-ATOMIC-CONCEPTS))) $\rightarrow 16$
(EVALUATE (LENGTH (ALL-ROLES))) $\rightarrow 12$
(EVALUATE (LENGTH (ALL-RULES))) $\rightarrow 2$

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Configuration
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CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

(GET-TBOX-LANGUAGE) $\rightarrow' L - C - RI'$

(GET-ABOX-LANGUAGE) $\rightarrow' L - C - RI(D)'$

(RELATED-INDIVIDUALS ISCOMPATIBLECARITEM) \rightarrow

((MACANREGULARSEATS)(MACANPARKINGSSENSORS)...)

(RELATED-INDIVIDUALS ISCOMPATIBLEITEMITEM) \rightarrow

((WOODTRIMMATRIXLEDLIGHTS)(WOODTRIMPANORAMIC

(RELATED-INDIVIDUALS ISINCLUDED) \rightarrow

((WOODTRIMNAPPALEATHER)(LEDLIGHTSMATRIXLEDLIGH

(INDIVIDUAL-FILLERS TAYCAN ISCOMPATIBLECARITEM)

\rightarrow

(SPORTSEATSFULLSAFETYSYSTEMNAPPALEATHERMATRIX

(CONCEPT-DISJOINT? WHEELS TECH) $\rightarrow T$

Racer Query Results

Car
Configuration
Ontology

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CQs and Use
Cases

TBox

ABox

Roles

Rules

Ontology
Design
Patterns

Racer Java
API

FuzzyDL

Queries

```
(INDIVIDUALS-RELATED? PARKINGSSENSORS
FULLSAFETYSYSTEM ISINCLUDED) → T
(EVALUATE (i
(RETRIEVE-INDIVIDUAL-TOLD-ATTRIBUTE-VALUE
(QUOTE HEATEDSEATS) (QUOTE HASPRICE)
(CURRENT-ABOX))
(RETRIEVE-INDIVIDUAL-TOLD-ATTRIBUTE-VALUE
(QUOTE REGULARSEATS) (QUOTE HASPRICE)
(CURRENT-ABOX)))) → T
(INDIVIDUALS-RELATED? TAYCAN BLINDSPOTMONITOR
ISCOMPATIBLECARITEM) → T
(INDIVIDUALS-RELATED? TAYCAN PARKINGSSENSORS
ISCOMPATIBLECARITEM) → T
(INDIVIDUALS-RELATED? BLINDSPOTMONITOR
WHEELS19 ISCOMPATIBLEITEMITEM) → T
```