Object-Oriented KRR with Flora-2 - Examples

CSE 505 – Computing with Logic

Stony Brook University

http://www.cs.stonybrook.edu/~cse505

Knowledge Representation and Reasoning with Flora-2

- Example: California Driver's Handbook in the section Speed Limit (page 28): "*Right-of-way rules, together with courtesy and common sense, help to promote traffic safety*".
  - Example from the Stanford CS227 course taught by Prof. Vinay K. Chaudhri
  - We need to represent the world (entities and events):

```
Event :: Thing.
Entity :: Thing.
```

  - DrivingSituation is a subclass of Event:

```
DrivingSituation :: Event.
```

  - DrivingEntity is a subclass of Entity to denote drivers:

```
DrivingEntity :: Entity.
```

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- SpatialEntity is a subclass of Entity to denote a geographical locations:

```
SpatialEntity :: Entity.
```

- Action is a subclass of Event and has a property agent with the range of Entity (we say that the domain of agent is Event):

```
Action :: Event [agent *=> Entity].
```

- Drive is a subclass of Action:

```
Drive :: Action.
```

- IllegalDrive is a subclass of Drive:

```
IllegalDrive :: Drive.
```

- Event has a property participant with the range of Entity:

```
Event :: Thing [participant *=> Entity].
```

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- DrivingSituation has a property rightOfTheWay with the range of DrivingEntity:

```
DrivingSituation :: Event [
   rightOfTheWay *=> DrivingEntity].
```

- Event has a property follows with the range of Event to denote an event that immediately follows the first:

```
Event[follows *=> Event].
```

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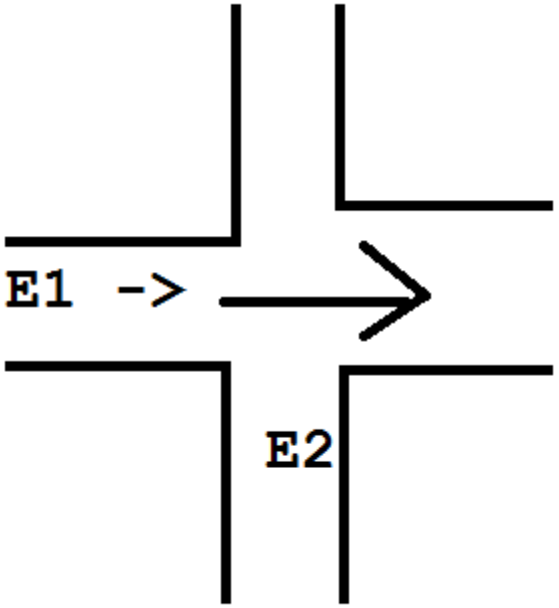
- If a driving entity takes a driving action in a situation in which it does not have the right of the way it is an instance of IllegalDrive:

```
?D : IllegalDrive :-
  ?E1 : Entity,
  ?E2 : Entity,
  not ?E1 :=: ?E2,
  ?S:DrivingSituation [
    participant -> ?E1,
    participant -> ?E2,
    rightOfTheWay -> ?E2]
  ?D : Drive [
    agent -> ?E1,
    follows -> ?S].
```



- Note: this rule uses the negation as failure symbol "not", and the equality symbol ":=:".

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- Debugging:
  - As we write each rule, we test it by creating an artificial situation and ensuring that it gives us the result we want.
  - Each rule should be tested in isolation, and also in a way that it interacts with other rules in the knowledge base.
  - We will give a test case for each rule as we introduce it.

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- A test case for the previous rule is:

```
P1 : DrivingEntity.
P2 : DrivingEntity.
D1 : Drive [ agent -> P1, follows -> S1].
S1 : DrivingSituation [
  participant -> P1,
  participant -> P2,
  rightOfTheWay -> P2].
```

- Then we pose a query as follows:

```
?- D1:IllegalDrive.
  Yes
```

- The expected answer of "Yes" confirms the intended behavior of this rule.

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- "*The right of the way is a necessary but not sufficient condition for a safe and legal driving action.*"

```
SafeDrive :: Drive.
?S [ rightOfTheWay -> ?E1] :-
  ?S : DrivingSituation [participant -> ?E1],
  ?E1 : DrivingEntity,
  ?_ : SafeDrive [follows -> ?S,
    agent -> ?E1].
```

- To test this rule, we introduce the following situation:

```
S2:DrivingSituation [participant -> P3].
P3: DrivingEntity.
D2: SafeDrive [ follows -> S2, agent -> P3].
```

- And pose the following query that confirms that the rule functions as expected:

```
?- S2[rightOfTheWay -> ?x].
  ?x = P3
```

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- "*Respecting the right-of-way of others is not limited to situations such as yielding to pedestrians in crosswalks, or watching carefully to ensure the right-of-way of bicyclists and motorcyclists*" introduces the notion that the right of the way is not just limited to yielding to others when needed, but it also means obeying the law as suggested in the sentence (a driving rule): "*Motorists must respect the right-of-way of others by not violating traffic laws such as failing to stop at a stop sign or traffic light, speeding, making unsafe lane changes, or illegal turns.*"
- This sentence is a general statement highlighting the importance of following the right-of-the-way law: "*Statistics show that right-of-way violations cause a high percentage of injury collisions in California.*"

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- A Person is an Entity and Pedestrian as its subclass:

```
Person :: Entity.
Pedestrian :: Person.
```

- Bicyclist, Motorist, and MotorCyclist are subclasses of DrivingEntity and Person:

```
Bicyclist :: (DrivingEntity, Person).
Motorist :: (DrivingEntity, Person).
MotorCyclist :: (DrivingEntity, Person).
```

- The class Crosswalk and StreetCorner are subclasses of SpatialEntity:

```
CrossWalk :: SpatialEntity.
StreetCorner :: SpatialEntity.
```

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- TrafficSign is a subclass of SpatialEntity, and StopSign and TrafficSign are its subclasses:

```
TrafficSign :: SpatialEntity.
StopSign :: TrafficSign.
TrafficSignal :: TrafficSign.
```

- FailToStopAtTrafficSign, Speeding, MakingIllegalTurn and MakingUnsafeLaneChange are subclasses of IllegalDrive:

```
FailToStopAtTrafficSign :: IllegalDrive.
Speeding :: IllegalDrive.
MakingIlliegalTurn :: IllegalDrive.
UnsafeLaneChange :: IllegalDrive.
```

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- Drive has a property violatesRightOfTheWayOf with the range Entity:

```
Drive :: Action [
  violatesRightOfTheWayOf *=> Entity].
```

- Any IllegalDrive violates the right of way of (represented by the property violatesRightOfTheWayOf) others that are also on the road:

```
?I [ violatesRightOfTheWayOf -> ?Q] :-
  ?_P : Entity,
  ?Q : Entity,
  not ?_P :=: ?Q,
  ?S : DrivingSituation [
    participant -> ?_P,
    participant -> ?Q],
  ?I : IllegalDrive [
    agent -> ?_P,
    follows -> ?S].
```

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- We test this rule by introducing the following situation:

```
P4 : Person.
P5 : Person.
S3 : DrivingSituation [ participant -> P4,
  participant -> P5].
I1 : FailToStopAtTrafficSign [agent -> P4,
  follows -> S3].
```

- We pose the following query:

```
?- I1 [violatesRightOfTheWayOf -> ?x].
  ?x = P5
  Yes
```

  - An answer of "Yes", and the correct binding for the query variable confirms the correct functioning of this rule.

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- "*Respect the right-of-way of pedestrians. Always stop for any pedestrian crossing at corners or other crosswalks, even if the crosswalk is in the middle of the block and at corners with or without traffic lights, whether or not the crosswalks are marked by painted lines*":

```
?S [ rightOfTheWay -> ?P] :-
  ?C : CrossWalk,
  ?P : Pedestrian,
  ?S : DrivingSituation [
    location -> ?C,
    participant -> ?P].
```

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- To test this rule, we introduce the following situation:

```
C1 : CrossWalk.
P6 : Pedestrian.
S4 : DrivingSituation [
  location -> C1,
  participant -> P6].
```

- And then pose the following query:

```
?- S4 [rightOfTheWay -> ?x].
  ?x = P6
  Yes
```

  - The correct answer confirms the encoding of the rule.

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- Debugging:
  - We will now consider a few example questions that exercise more than one rule at a time:
  - Question: "*A car and pedestrian are stopped at a corner. If the car proceeds whose right of the way will it violate?*"
    - To answer this question, the system first needs to determine that the pedestrian has the right of the way, and by noticing that the car violates the right of the way conclude that it is an illegal drive, from which it can conclude that this drive must violate the right of the way of the pedestrian.

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- Program:

```
P7 : Car.
P8 : Pedestrian.
C3 : StreetCorner.
S6 : DrivingSituation [
  location -> C3,
  participant -> P8,
  participant -> P7].
D3 : Drive [
  agent -> P7,
  follows -> S6].
```

- We pose the query:

```
?- D3 [ violatesRightOfTheWayOf -> ?x].
  ?x = P8
  Yes
```

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- Question: "*If I do not stop at a traffic sign, do I violate somebody's right of the way?*"
- Program:

```
P9: Entity.
P10 : Entity.
S7 : DrivingSituation [
  participant -> P9,
  participant -> P10].
F1:FailToStopAtTrafficSign [
  agent -> P9,
  follows -> S7].
```

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- Answering this question requires using inheritance to conclude that FailToStopAtTrafficSign is an IllegalDrive, and then using a rule to conclude that this action must violate the right of the way of the person who might be at the same location.

```
?- F1 [ violatesRightOfTheWayOf -> ?x].
  ?x = P10
  Yes
```