

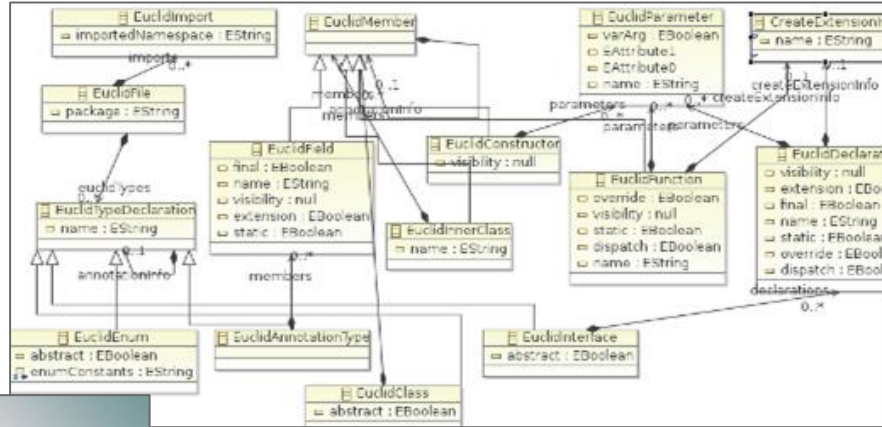
SIU/CAPES bilateral project "Modern Refactoring"



Angela Barriga, Adrian Rutle and Rogardt Heldal

Automatic model repair using reinforcement learning

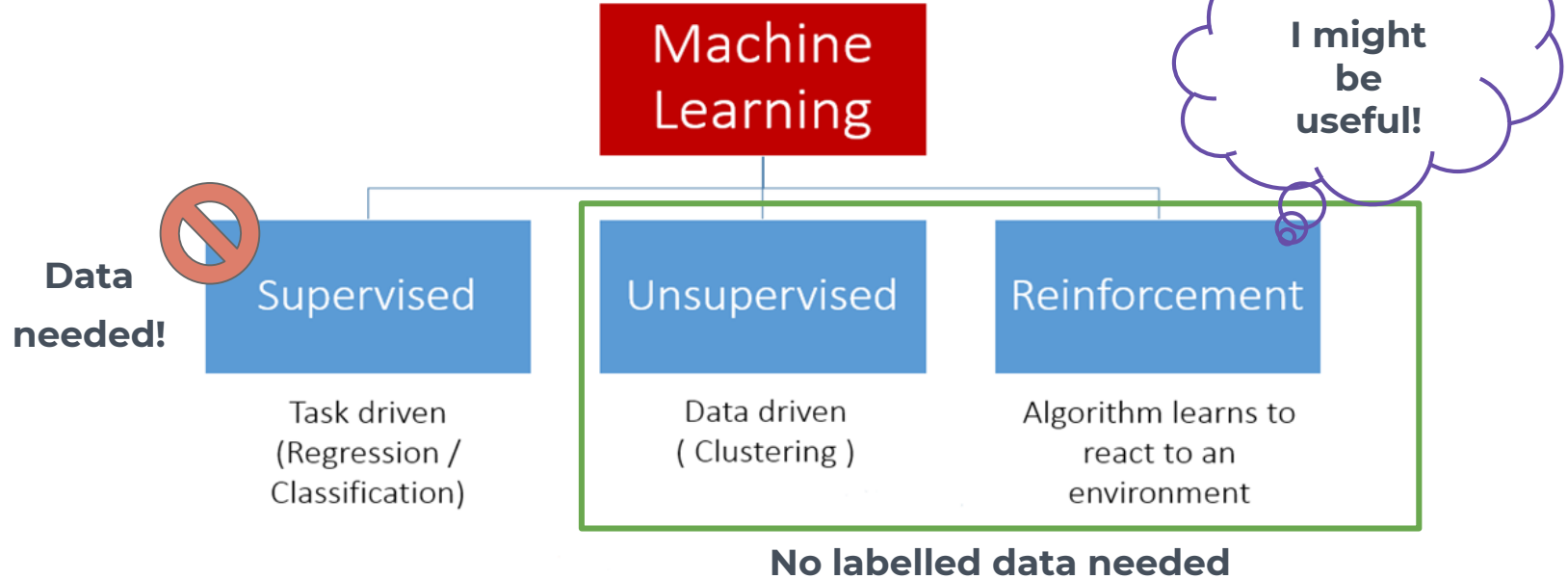
The importance of model repairing



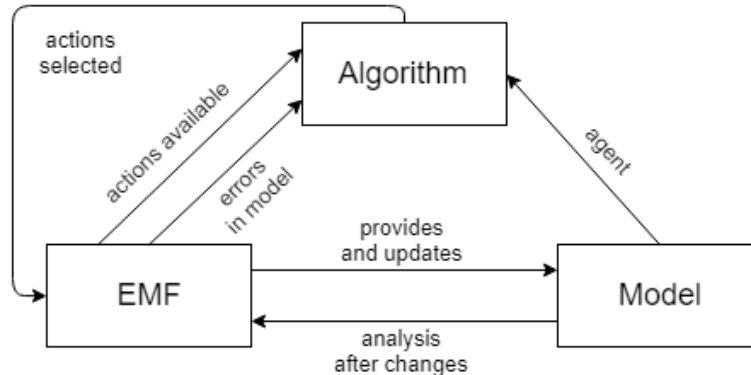
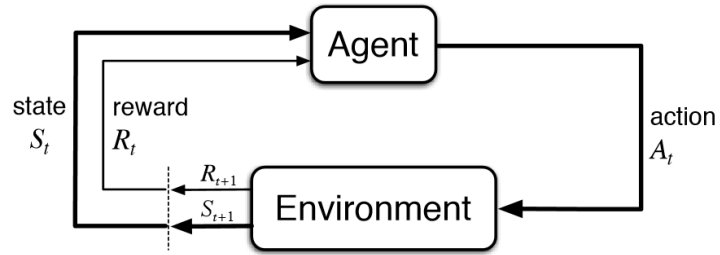
Why not **Machine Learning**?

No data? No problem

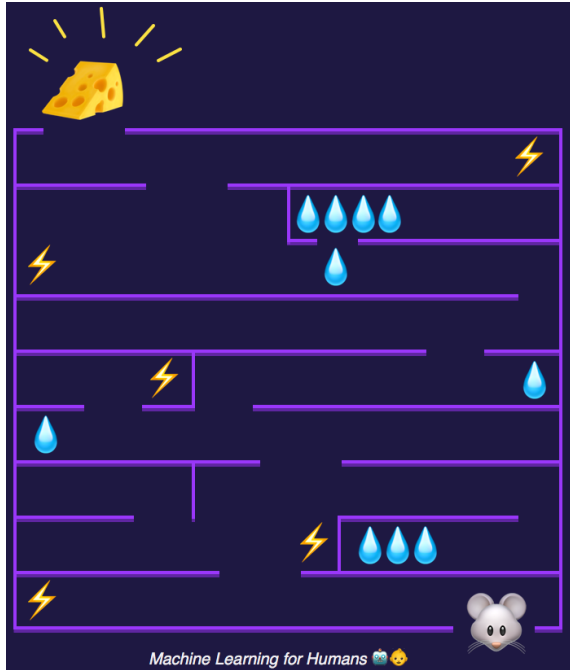
Types of Machine Learning



Reinforcement learning

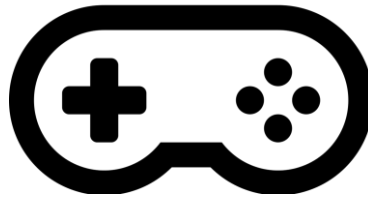


Q-Learning



$$Q_{t+1}(s_t, a_t) = Q_t(s_t, a_t) + \alpha(r_{t+1} + \gamma \max_a Q_t(s_{t+1}, a) - Q_t(s_t, a_t))$$

$$Q(s, a) = r + \gamma \max_{a'} Q(s', a')$$



Example

Errors

0. Duplicate attribute name
1. Attribute without type
2. Self super type
3. Duplicate class name

Actions

0. Rename class
1. Delete super type
2. Rename attribute
3. Add type to attribute

Algorithm 1 AMRT Algorithm

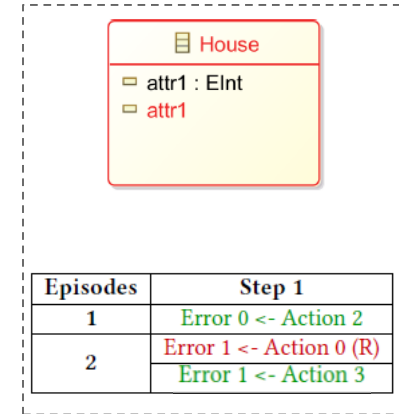
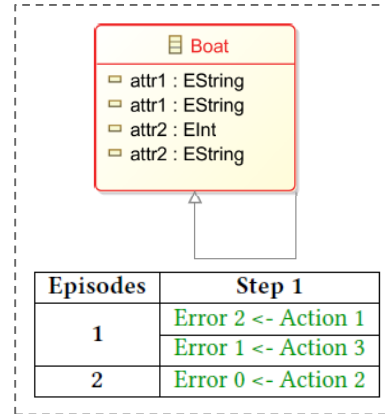
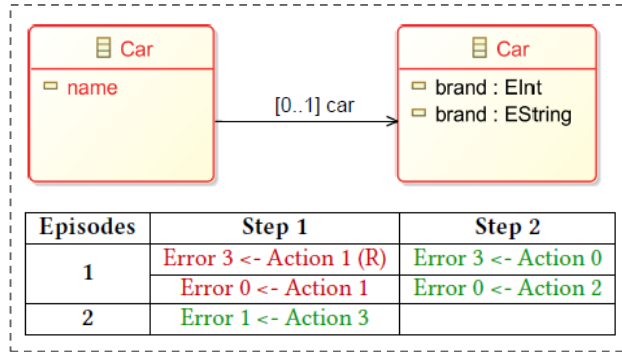
```

Initialize: Q-matrix, Gamma
INPUT: from EMF (Model, Actions, Errors)
while Episodes not empty do
  for each Error s do
    for Steps in Episode do
      Select Action a // random or highest Q-value
      Evaluate changes in Model produced by a
      Update Q-table
    if s is solved then
      Delete s
      Exit for
    else
      s' ← s // s' stores s modified by a
      Save s' in Errors
  
```

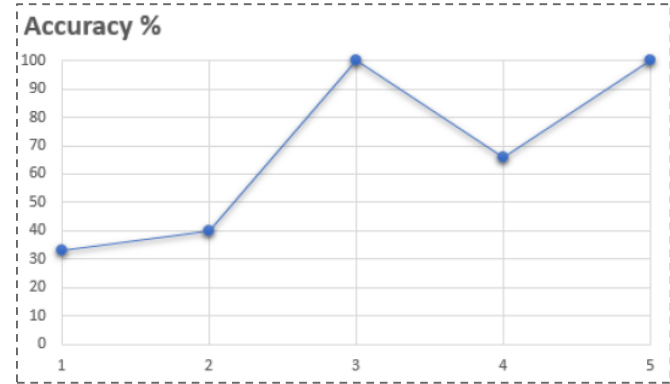
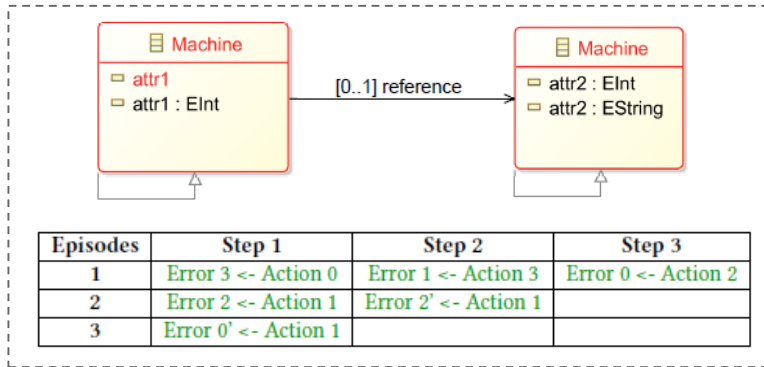


Episodes	Step 1	Step 2	Step 3
1	Error 0 <- Action 0	Error 0 <- Action 2 (R)	
	Error 2 <- Action 0	Error 2 <- Action 1	
2	Error 1 <- Action 0	Error 1 <- Action 1	Error 1 <- Action 2
3	Error 1 <- Action 1 (R)	Error 1 <- Action 3	

Example evaluation



Example evaluation II



Current status I

- **Integration with EMF** achieved by using EMF API: actions and errors.

- **Mutation testing** by using Ecore Mutator (by Johannes Kepler University of Linz and Vienna University of Technology).



Example - errors

4 errors found

- platform:/resource/Validator%20test/models/myTest.ecore
 - library
 - Library
 - n..m _mPTwULgIEeiTS-Jal5LKxw()
 - member : Member
 - ecoremutator
 - _mPaeALgIEeiTS-Jal5LKxw
 - member : Member
 - Member
 - name : EString
 - library : Library
 - Book
 - copies : EBigInteger
 - library : Library

The name '**_mPTwULgIEeiTS-Jal5LKxw**' is not well formed - **EOperation**

An operation with void return type must have an upper bound of 1 not 27 - **EOperation**

The opposite of a transient reference must be transient if it is proxy resolving - **EReference**

The name 'null' is not well formed - **EClass**

48 actions extracted in total

Example - solution

- platform:/resource/Validator%20test/models/myTest.ecore
 - library
 - Library
 - placeholder37269110
 - member : Member
 - placeholder2546881
 - Member
 - name : EString
 - library : Library
 - Book
 - copies : EBigInteger
 - library : Library

Actions discarded: getters...

Only applying if Error and Action with same origin

46 invocations

Generic Q-table for EMF

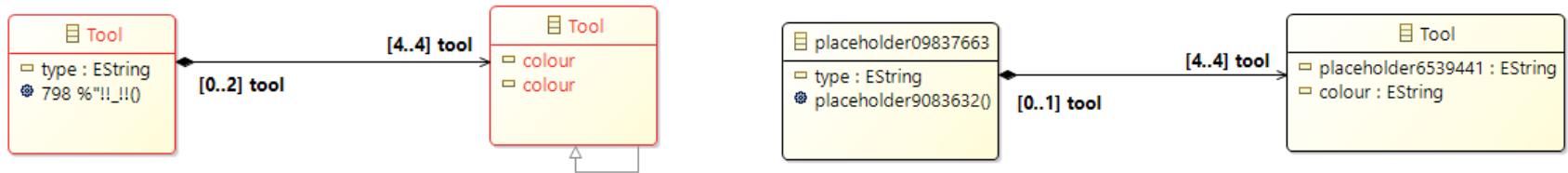
Current status II



- **All possibilities:** the algorithm finds all possible actions to fix an error.
- **Sequences:** the algorithm show all possible sequences to fix the model.
- **Rewards tuning at two levels:** individual actions and sequences.

Sequence example

12 sequences found



-----:::BEST SEQUENCE IS:::-----

```
Sequence [id=1, seq=[ErrorAction [error=29 There may not be two classifiers named 'Tool', action=-1193116178 setName 2 -1]
, ErrorAction [error=442 The name '798 %"!_!!()' is not well formed, action=1614867400 setName 1 -1]
, ErrorAction [error=26 A class may not be a super type of itself, action=-1184341393 unsetEGenericSuperTypes 1 -1]
, ErrorAction [error=32 There may not be two features named 'colour', action=-801382182 setName 2 -1]
, ErrorAction [error=40 The typed element must have a type, action=591449609 setType 1 -1]
, ErrorAction [error=28 A container reference must have upper bound of 1 not 2, action=1062131977 setContainmentGen 1 -1]
, ErrorAction [error=40 The typed element must have a type, action=591449609 setType 1 -1]
], weight=2600.0]
```

But...?

- **The search space can get crazy:** Yes, but we are planning to reduce it with optimization techniques + a strong HCI layer.
- **Only semantic errors?** For now yes, but the approach is generic and can be easily adapted.
- **Still getting started!**



Together, stronger



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