

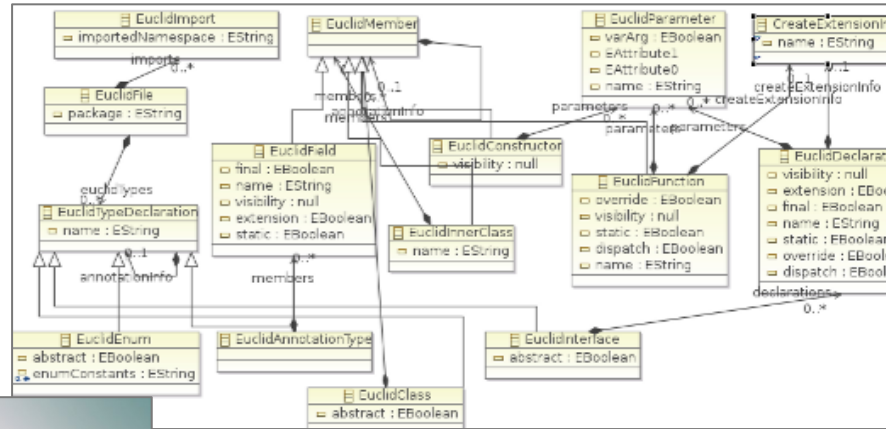


Angela Barriga, Adrian Rutle and Rogardt Heldal

# Automatic model repair using reinforcement learning

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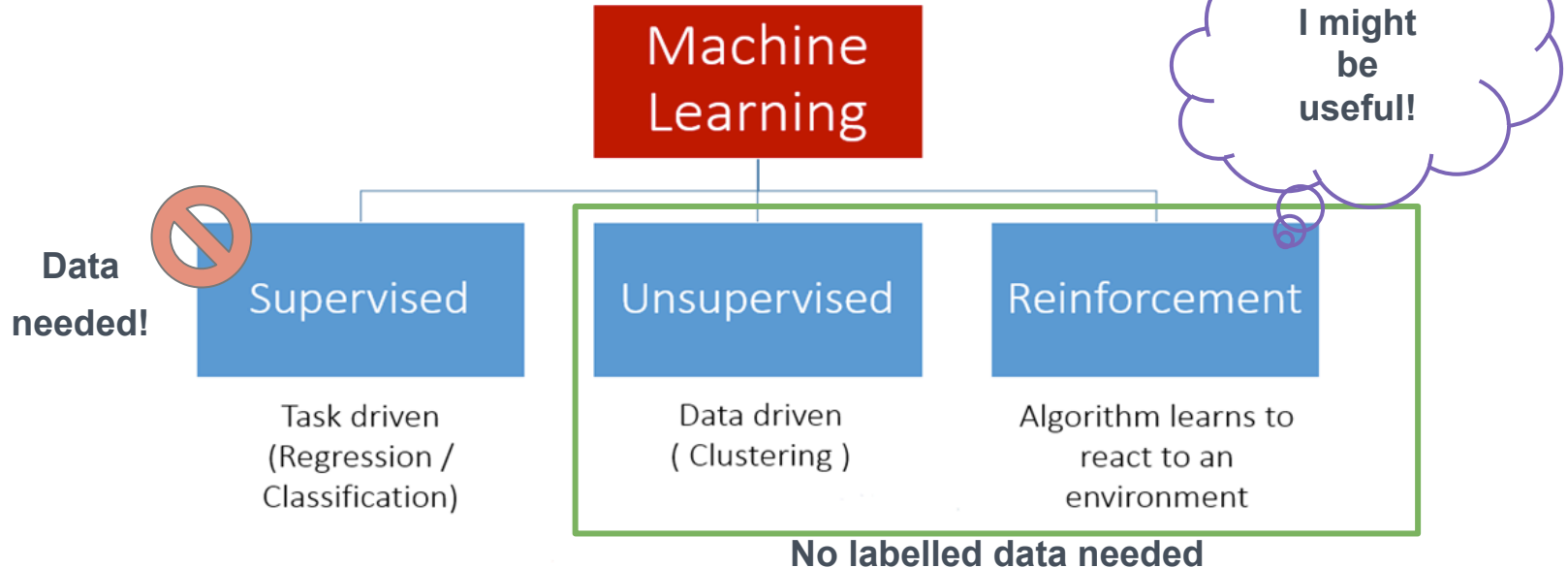
# The importance of model repairing



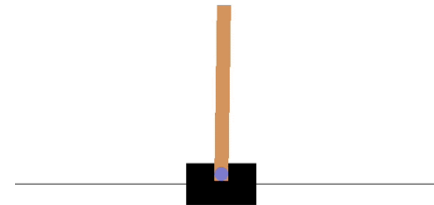
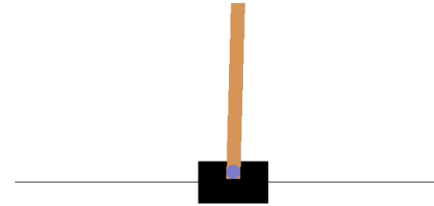
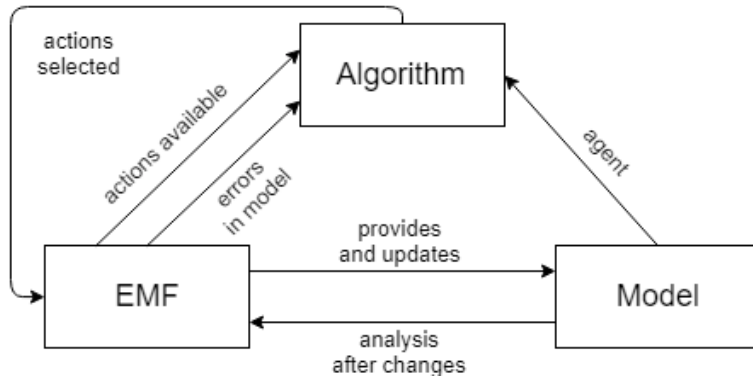
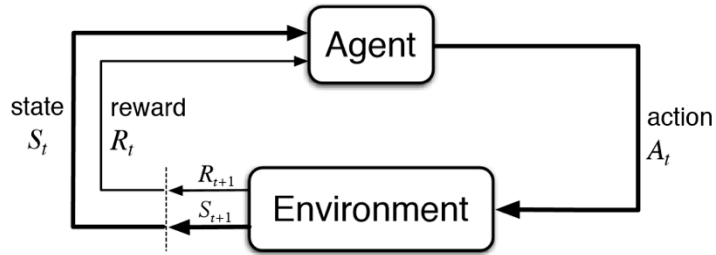
Why not Machine Learning?

# No data? No problem

## Types of Machine Learning



# Reinforcement learning

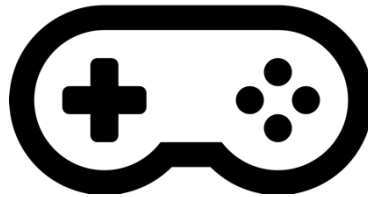


# Q-Learning



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

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



# 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 super type
3. Add type to attribute

### Algorithm 1 AMRT Algorithm

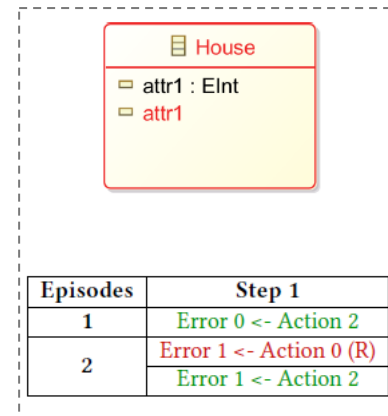
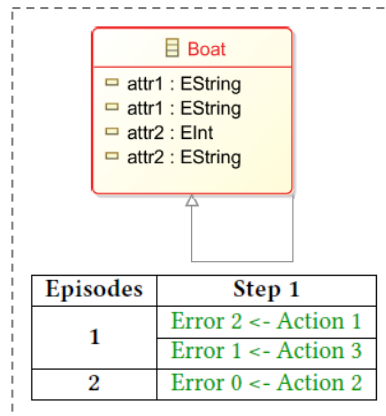
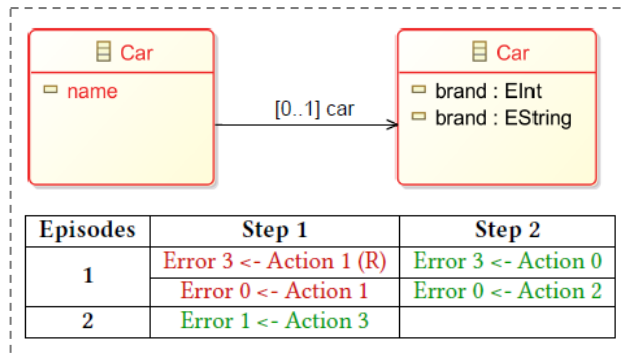
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Initialize: Q-matrix, Gamma
INPUT: from EMF (Model, Actions, Errors)
while Episodes not empty do
  for each Error s do
    for Steps in Episode do
      Select Action a // random or highest Q-value
      Evaluate changes in Model produced by a
      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
  
```

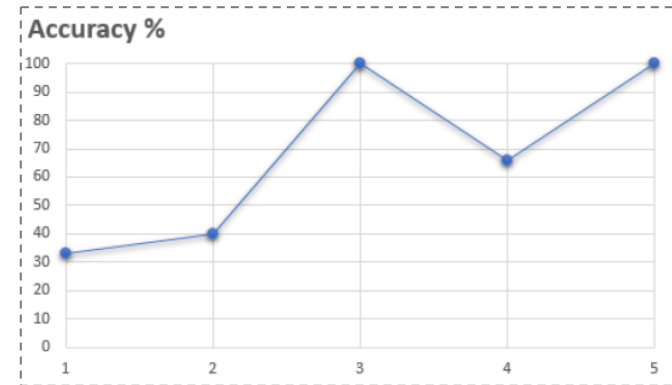
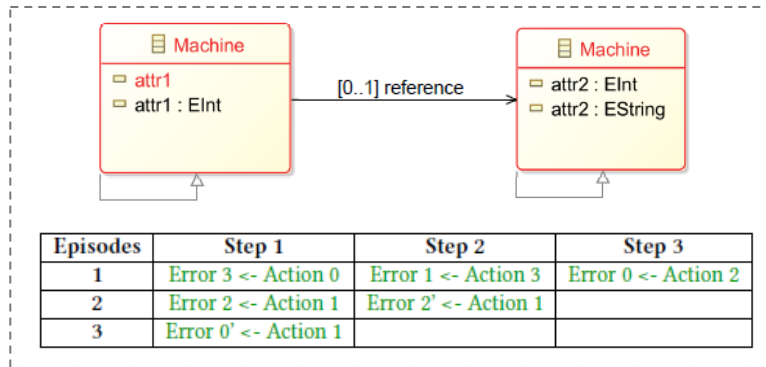


| Episodes | Step 1                  | Step 2                  | Step 3              |
|----------|-------------------------|-------------------------|---------------------|
| 1        | Error 0 <- Action 0     | Error 0 <- Action 2 (R) |                     |
|          | Error 2 <- Action 0     | Error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

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- **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 \_mPTwULglEeiTS-Jal5LKxw()
      - member : Member
    - ecoremutator
      - \_mPaeALglEeiTS-Jal5LKxw
      - member : Member
    - Member
      - name : EString
      - library : Library
    - Book
      - copies : EBigInteger
      - library : Library

The name '\_mPTwULglEeiTS-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

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- 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**

# Together, stronger

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