Artificial Intelligence

Algorithms and Applications with Python

Lectorial 03

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Agenda

3.1 Basics and Repetition

3.2 Building a Rule-Based Agent for Credit Scoring

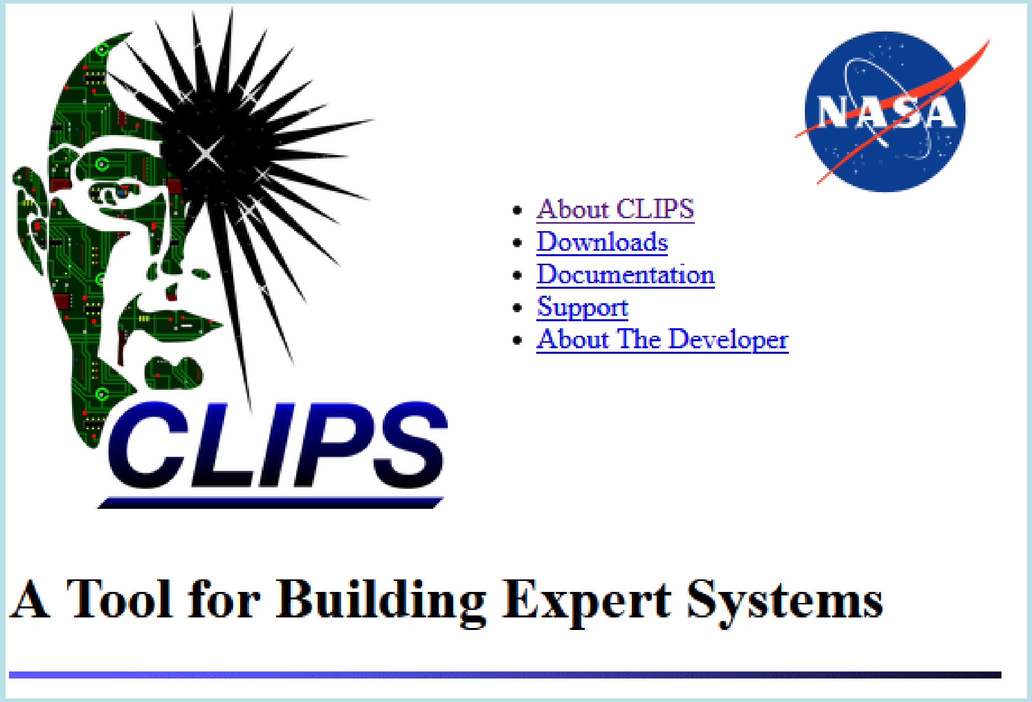
Note

- This is a lectorial: I will explain/repeat the most important concepts and then you try to solve the programming task by your own

- You are explicitly encouraged to solve this task in groups. And I will help you and give suggestions. However, there is no perfect solution, you will get a possible solution.

- If the task is too hard for you at the moment – relaxe ☺. Just look at the task again at a later point in the course.

C Language Integrated Production System (CLIPS)



- About CLIPS
- Downloads
- Documentation
- Support
- About The Developer

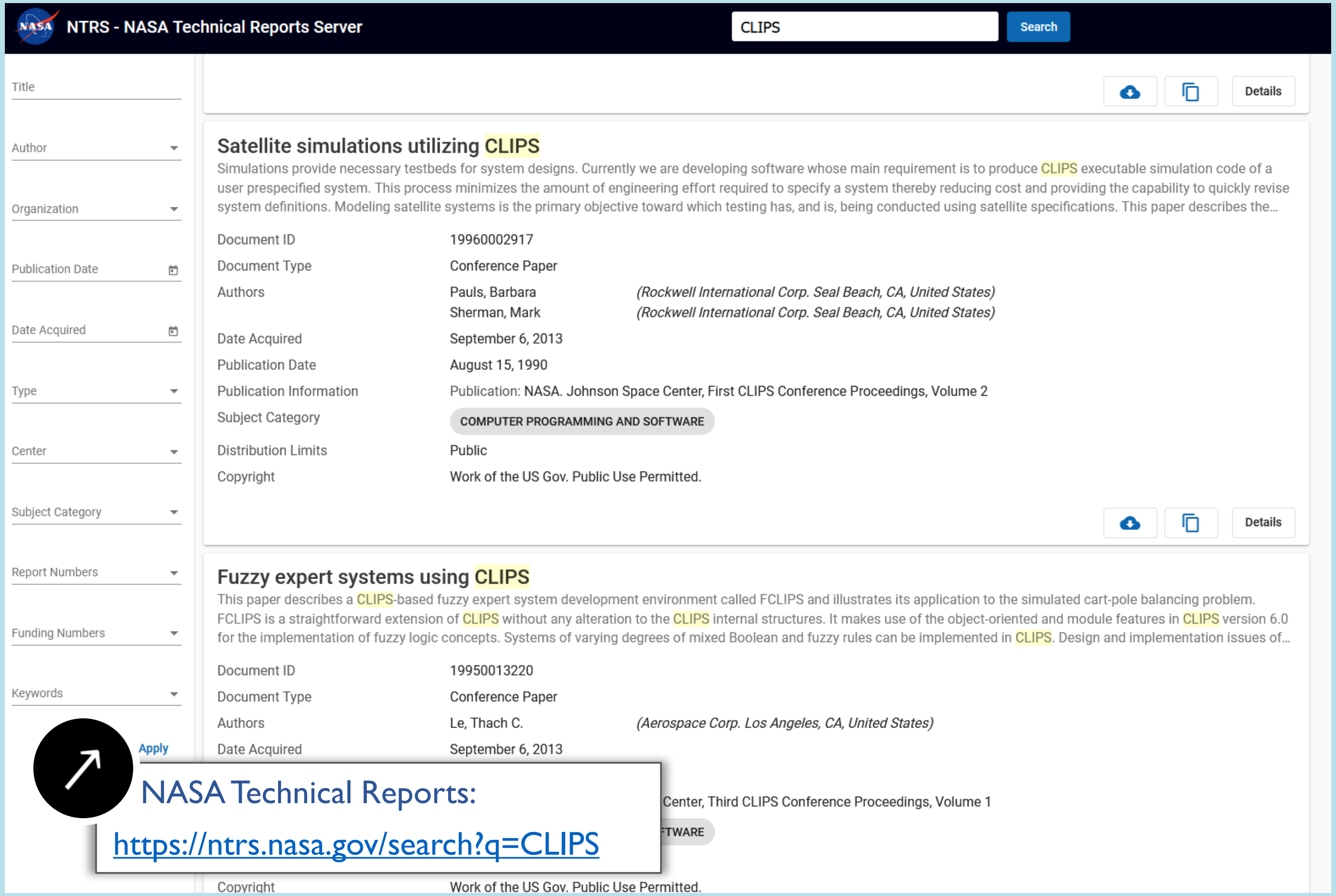
A Tool for Building Expert Systems

↗ CLIPS A Tool for Building Expert Systems: www.clipsrules.net

- CLIPS is probably the most widely used expert system tool
- Designed using the C language at the NASA/Johnson Space center
- Multiparadigm programming language (rule-based, object-oriented, procedural)
- Many Python alternatives available, PyKnow/Experta are the most popular. However, they do not reach the power of pure CLIPS (performance, expressions etc.)

Image sources: ↗ Wikipedia (2020) by National Aeronautics and Space Administration; ↗ www.clipsrules.net (2020)

CLIPS Applications in Science and Engineering



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CLIPS Search

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Details

Satellite simulations utilizing CLIPS

Simulations provide necessary testbeds for system designs. Currently we are developing software whose main requirement is to produce CLIPS executable simulation code of a user prespecified system. This process minimizes the amount of engineering effort required to specify a system thereby reducing cost and providing the capability to quickly revise system definitions. Modeling satellite systems is the primary objective toward which testing has, and is, being conducted using satellite specifications. This paper describes the...

Document ID	19960002917	
Document Type	Conference Paper	
Authors	Pauls, Barbara	*(Rockwell International Corp. Seal Beach, CA, United States)*
	Sherman, Mark	*(Rockwell International Corp. Seal Beach, CA, United States)*
Date Acquired	September 6, 2013	
Publication Date	August 15, 1990	
Publication Information	Publication: NASA. Johnson Space Center, First CLIPS Conference Proceedings, Volume 2	
Subject Category	COMPUTER PROGRAMMING AND SOFTWARE	
Distribution Limits	Public	
Copyright	Work of the US Gov. Public Use Permitted.	

Details

Fuzzy expert systems using CLIPS

This paper describes a CLIPS-based fuzzy expert system development environment called FCLIPS and illustrates its application to the simulated cart-pole balancing problem. FCLIPS is a straightforward extension of CLIPS without any alteration to the CLIPS internal structures. It makes use of the object-oriented and module features in CLIPS version 6.0 for the implementation of fuzzy logic concepts. Systems of varying degrees of mixed Boolean and fuzzy rules can be implemented in CLIPS. Design and implementation issues of...

Document ID	19950013220	
Document Type	Conference Paper	
Authors	Le, Thach C.	*(Aerospace Corp. Los Angeles, CA, United States)*
Date Acquired	September 6, 2013	
	Center, Third CLIPS Conference Proceedings, Volume 1	
	FTWARE	
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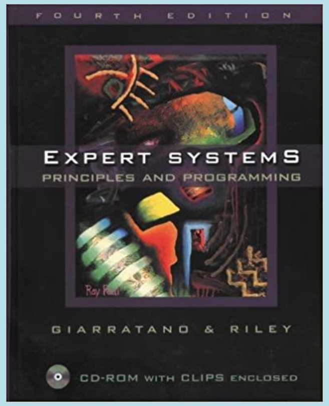
↗ NASA Technical Reports:

https://ntrs.nasa.gov/search?q=CLIPS

- Many NASA realworld scientific applications of CLIPS expert systems in Engineering and Science available on the NASA Technical Report Server

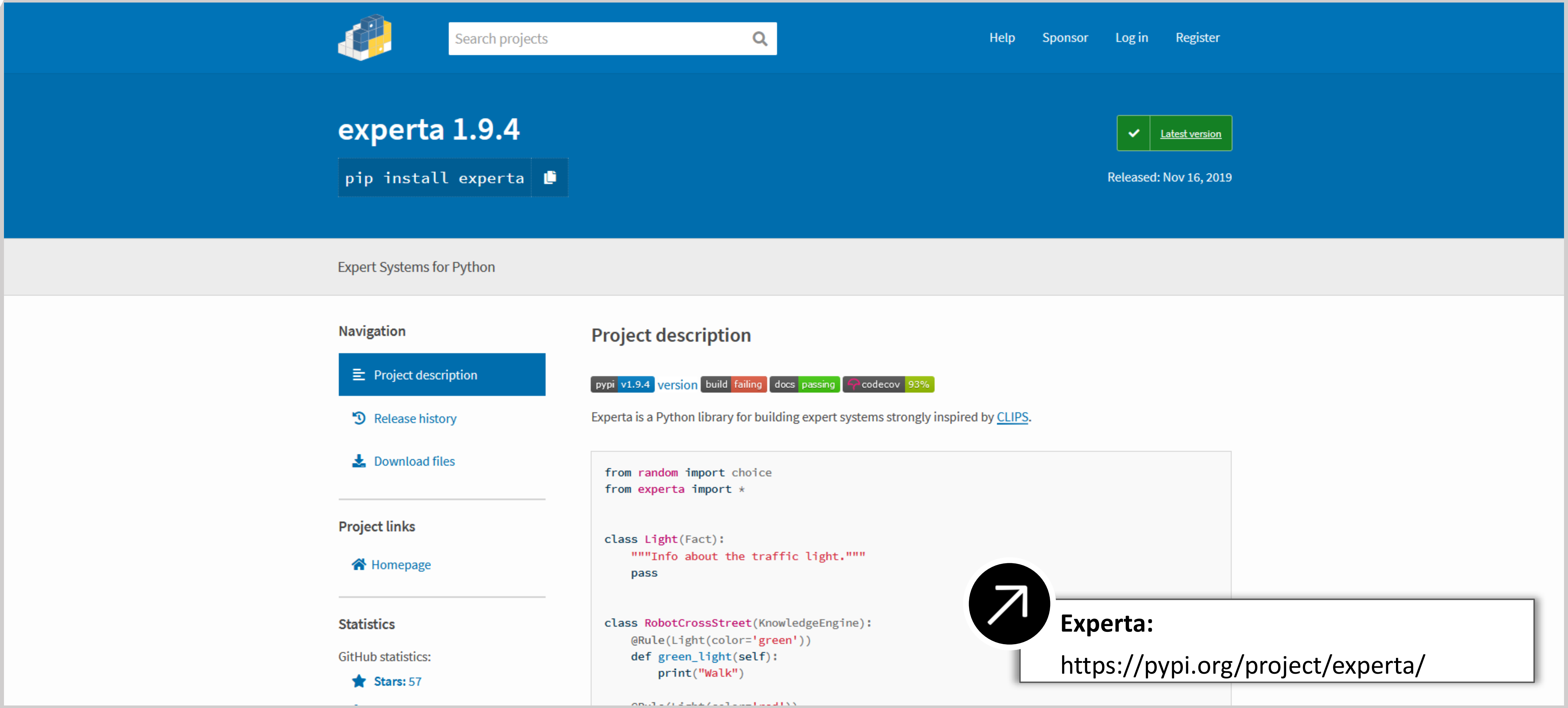


Giarratano, J. C., & Riley, G. (1989). *Expert systems: principles and programming*. Brooks/Cole Publishing Co..

Age of Empires II Uses CLIPS for AI Opponents

Image sources: Microsoft Game Studios's Age of Empires II, Screenshot by my own

Experta (Python CLIPS Implementation)



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experta 1.9.4

```
pip install experta
```

Latest version

Released: Nov 16, 2019

Expert Systems for Python

Navigation

Project description

Release history

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Homepage

Statistics

GitHub statistics:

Stars: 57

Project description

pypi v1.9.4 version build failing docs passing codecov 93%

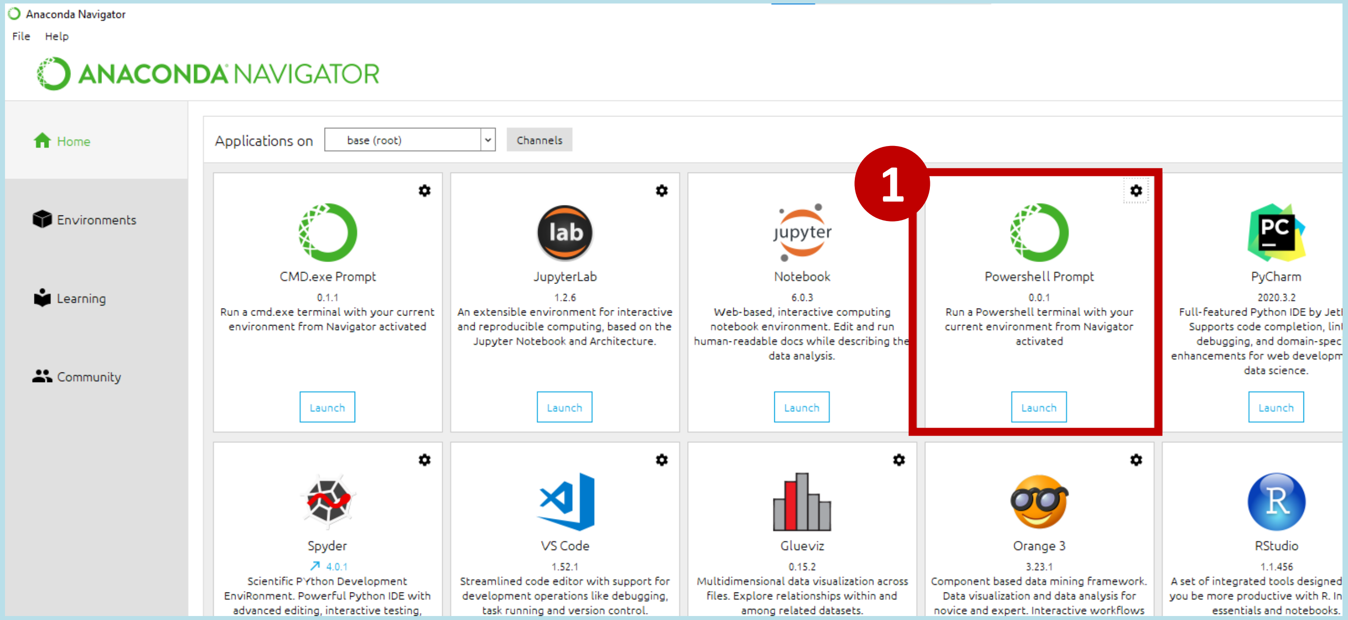
Experta is a Python library for building expert systems strongly inspired by CLIPS.

```
from random import choice
from experta import *


class Light(Fact):
    """Info about the traffic light."""
    pass


class RobotCrossStreet(KnowledgeEngine):
    @Rule(Light(color='green'))
    def green_light(self):
        print("Walk")
```

Experta:

https://pypi.org/project/experta/

Install Experta



CMD.exe Prompt
0.1.1
Run a cmd.exe terminal with your current environment from Navigator activated

JupyterLab
1.2.6
An extensible environment for interactive and reproducible computing, based on the Jupyter Notebook and Architecture.

Notebook
6.0.3
Web-based, interactive computing notebook environment. Edit and run human-readable docs while describing the data analysis.

Powershell Prompt
0.0.1
Run a Powershell terminal with your current environment from Navigator activated

PyCharm
2020.3.2
Full-featured Python IDE by Jet Supports code completion, lin debugging, and domain-spec enhancements for web developm data science.

Spyder
4.0.1
Scientific PYthon Development EnviRonment. Powerful Python IDE with advanced editing, interactive testing,

VS Code
1.52.1
Streamlined code editor with support for development operations like debugging, task running and version control.

Glueviz
0.15.2
Multidimensional data visualization across files. Explore relationships within and among related datasets.

Orange 3
3.23.1
Component based data mining framework. Data visualization and data analysis for novice and expert. Interactive workflows

RStudio
1.1.456
A set of integrated tools designed you be more productive with R. In essentials and notebooks.

- Experta is not available in the default anaconda repository, hence we have to install it from pypi
- Start your anaconda shell

- And type in the following pip install command:

2

```
pip install experta
```

`Facts` in Experta/PyKnow

- `Facts` are the basic unit of information. They are used by our inference algorithm to reason about the problem

```
>>> my_car = Fact(model="911 Turbo", horsepower=572)
>>> print(my_car["model"])

911 Turbo
```

- The `Fact` class is a subclass of `dictionnaries`, we already know from lecture 3

- The order of arguments is arbitary in `facts`. Hence, the arguments can be created without keys, or mixed with key-values.

Adapted from ↗Experta Documentation

Express Facts

- You can define facts and use them later in your code

```
>>> class Status(Fact):
>>>     pass

>>> my_fact = Status(color = "red")
>>> print(my_fact)

Status(color='red')
```

Adapted from ↗Experta Documentation

Define Default Facts with `DefFacts`

- Most of the time our knowledge-based system needs a set of facts to work with. For that purpose we can use the `DefFacts` decorator

```
@DefFacts()
def needed_data():
    yield Fact(car_color="red")
    yield Fact(price=170000)
```

- All `DefFacts` will be executed when we call the `reset()` method

Adapted from ↗Experta Documentation

Implement Rules

- We can also implement the two components of rules

$$\overbrace{if\ my\_car = 911}^{\textit{left-hand-side}} \rightarrow \overbrace{me = happy}^{\textit{right-hand-side}}$$

```
class my_fact(Fact):
    pass

@Rule(my_fact())
def matchWithEveryMyFact():
    pass
```

This is the left-hand-side of the rule

This is the right-hand-side of the rule

- The left-hand-side of the rule describes the conditions on which the rule should be executed (fired)
- The right-hand-side describe the set of actions to perform, when the rule is fired

Adapted from ↗Experta Documentation

Field Conditions and Rules

- We can implement different field conditions in our rules

```
@Rule(Fact(car = L(911) | L(718)))
def foo():
    pass
```

- Literal Field Contstraint
- Check if the car element is exactly „911“ or „718“

```
@Rule(Fact(name = W()))
def foo():
    pass
```

- Wildcard Field Contstraint
- Check if there is a fact with the key „name“

```
@Rule(Fact(P(lambda x:
isinstance(x, int)))
```

- Predicate Field Constraint
- Apply a callable to the fact-extracted value

Adapted from ↗Experta Documentation

Conditional Elements and Complexe Rules I

- In most cases we want to express more complicated rules. We can do that with different conditions

```
@Rule(AND(Fact(1), Fact(2)))
def foo():
    pass
```

- In an `AND` pattern, all of the passed conditions must match

```
@Rule(OR(Fact(1), Fact(2)))
def foo():
    pass
```

- In an `OR` pattern, any of the pattern will make the rule match

```
@Rule(NOT(Fact(1)))
def foo():
    pass
```

- With `NOT`, we can express the absence of a condition

Adapted from ↗Experta Documentation

Conditions and Complexe Rules II

- In most cases, we want to express more complicated rules. We can do that with different conditions

```
@Rule(EXISTS(Color()))
def foo():
    pass
```

- Check if one or more facts matches this pattern
- Will match only once while one or more matching facts exists

```
@Rule(FORALL(Student(W("name")),
        Exam(W("name")))

def all_students_passed():
    pass
```

- In `FORALL` pattern, we can check if a group of specified conditions is statisfied for every occurrence of another specified condition

Adapted from ↗Experta Documentation

Working with Variable Bindings

- You can also bind variables to a name with the << operator.
- For instance, we can bind the first value of the matching fact to a name, e.g. „value“ and pass it to the function when fired:

```
@Rule(Fact(MATCH.value))
def foo(value):
    pass
```

```
@Rule(Fact("value" << W()))
def foo(value):
    pass
```

- Or we can do it for the whole matching fact

```
@Rule(As.my_fact Fact(W()))
def foo(my_fact):
    pass
```

```
@Rule(Fact("my_fact" << Fact()))
def foo(my_fact):
    pass
```

Adapted from ↗Experta Documentation

The Inference or `KnowledgeEngine`

- The `KnowledgeEngine` is the main part of your knowledge-base system:

```
class helloWorld(KnowledgeEngine):
    @DefFacts()
    def _initial_action(self):
        yield Fact(action="say_hello")

    @Rule(Fact(action="say_hello"), NOT(Fact(name=W())))
    def ask_name(self):
        self.declare(Fact(name=input("Hey, what's your name? ")))

    # … more rules here …

    @Rule(Fact(action="say_hello"), Fact(name="name" << W()))
    def greet(self, name):
        print("Hi ", name)
```

Adapted from ↗Experta Documentation

Express Facts

```
>>> engine = helloWorld()
>>> engine.reset()
>>> engine.run()

Hey, what's your name? Dominik
Hi Dominik
```

- In a productive system, we initialize it and populate it step by step with further facts, then we run it for inference

Adapted from ↗Experta Documentation

Classroom Case

You can find the solution of each lectorial online in the git repository if you need some starting help!

Case

Your next job is in the *Financial Services Department*. You where ordered to build a credit scoring agent to automate most of the manual assessments of creditworthiness. Based on some first interviews you have noted the following comments:

Extract expert interview:

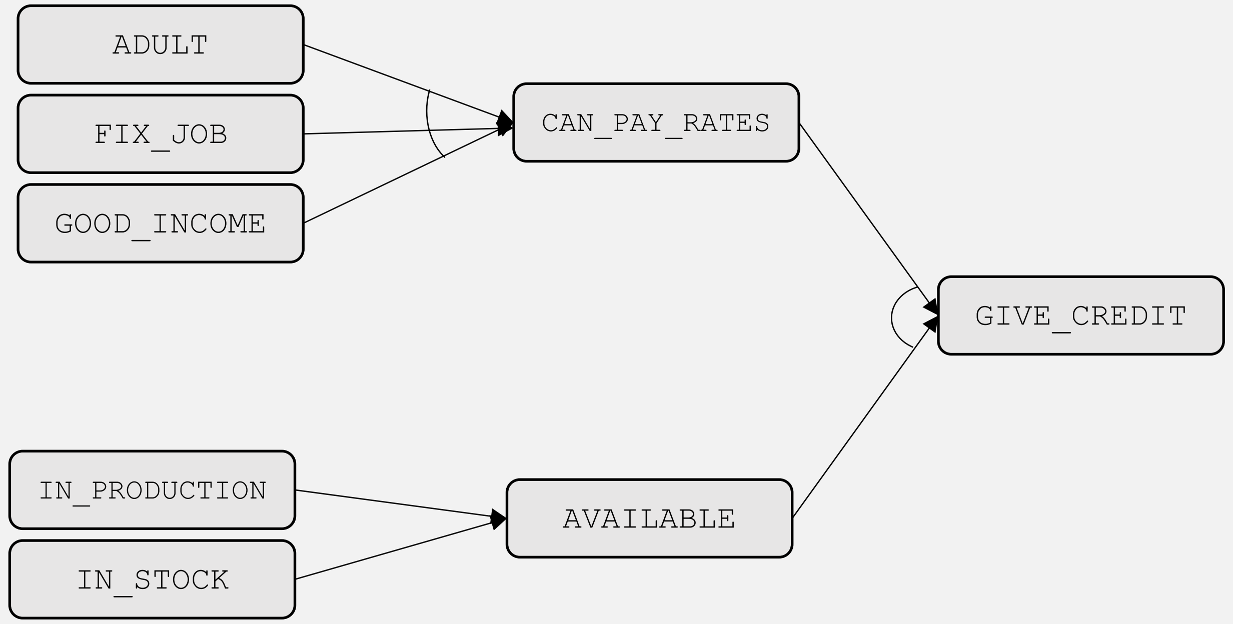
- *"In general we have customer, order or warehouse information that influence our car credit process. Our input fields in the credit system are credit and financial information and the ordered car model."*
- *"A customer can only get a car credit if he is adult, has a fix job and good income. We need this information to assess if he can pay the future credit rates of the car credit."*
- *"If a customer can pay the future car credit rates and the car is available we can give the credit"*
- *"A car can be in stock or we have to produce it. If it can be produced or if it's in stock the car is available for sale"*
- *"Due to the great success of our cars, we have currently no cars in stock. And we can only produce Taycans and 911."*

Please create a rule-based agent to automate the credit scoring process. Start with drawing a first sketch of the rule-network, and write down the input variables.

Then implement a first prototype with Python and Experta. You can start with the agent template for this lectorial or build your own agent from scratch (Lectorial 3 - Rule-based Agent Template.py).

1. Draw a Sketch of the Rule-Network

1. *"In general we have customer, order or warehouse information that influence our car credit process. Our input fields in the credit system are credit and financial information and the ordered car model."*
2. *"A customer can only get a car credit if he is adult, has a fix job and good income. We need this information to assess if he can pay the future credit rates of the car credit."*
3. *"If a customer can pay the future car credit rates and the car is available we can give the credit"*
4. *"A car can be in stock or we have to produce it. If it can be produced or if it's in stock the car is available for sale"*
5. *"Due to the great success of our cars, we have currently no cars in stock. And we can only produce Taycans and 911."*

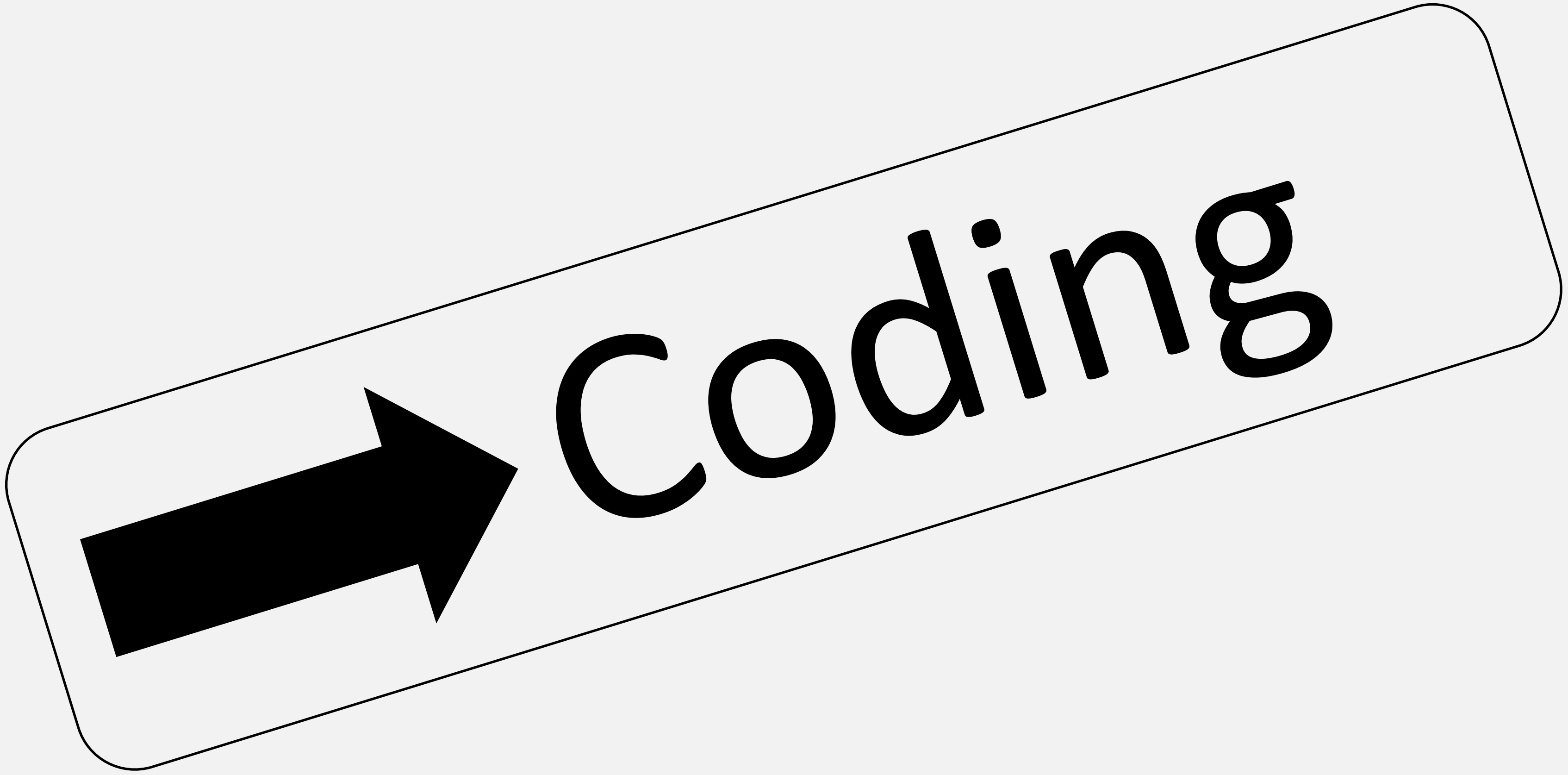


- Rule-networks give an good overview of the different relationships in our knowledge base
- We will use this rule-network for the next step, the agent implementation
- Input variables:

ADULT
CAR_MODEL
FIX_JOB
GOOD_INCOME

? Any suggestions for possible categories to organize our rules?

Further questions?



2. Structure of the Agent

```
#%% import python libs
from experta import *

#%% Knowledge engine and rule base
class CreditScoring(KnowledgeEngine):
    @DefFacts()
    def _initial_action(self):
        pass

    @Rule(..)

#%% Implement scoring agent
class CreditScoringAgent():
    def inference(self):
        pass

#%% Run agent
agent = CreditScoringAgent()
agent.inference()
```

- In a first step we define the rule-base
- In a second step, the agent logic is implemented

2.1 Implement `Fact` Classes

- In a first step, we load the template and implement our three kind of fact classes (alternatively you can store them directly as `Fact()`)

```
#%% import python libs
from experta import *

#%% Rule-based system
class Customer(Fact):
    """ All info about the customer's credibility """
    pass

class Order(Fact):
    """ Order related information like model etc. """
    pass

class Warehouse(Fact):
    """ Company information about the car production """
    pass
```

! These categories are just suggestions, you can also use other categories or just work with facts!

2.2 Implement Rules

- In the next step, let us take a look at the rules and fact definitions

```
class CreditScoring(KnowledgeEngine):
    @DefFacts()
         ?

    @Rule()
    def _(self):
        pass
```

? What is the difference between DefFacts and Rule? Where would you store which kind of information?

```
class CreditScoring(KnowledgeEngine):
     @DefFacts()
         def _initial_action(self):
        yield Warehouse(in_stock=False)
```

"Due to the great success of our cars, we have currently no cars in stock"

2.2 Implement `Rules` (Agent logic)

```
class CreditScoring(KnowledgeEngine):
    …
```

Rule 1: A customer can only get a car credit if he is adult, has a fix job and good income. We need this information to assess if he can pay the future credit rates of the car credit

Rule 2: … And we can only produce Taycans and 911.”

Rule 3: “A car can be in stock or we have to produce it. If it can be produced or if it’s in stock the car is available for sale”

Rule 4: “If a customer can pay the future car credit rates and the car is available we can give the credit”

- “In general we have customer, order or warehouse information that influence our car credit process”
- “A customer can only get a car credit if he is adult, has a fix job and good income. We need this information to assess if he can pay the future credit rates of the car credit.”
- “If a customer can pay the future car credit rates and the car is available we can give the credit”
- “A car can be in stock or we have to produce it. If it can be produced or if it’s in stock the car is available for sale”
- “Due to the great success of our cars, we have currently no cars in stock. And we can only produce Taycans and 911.”

2.2 Implement `Rules` (Agent logic)

```
class CreditScoring(KnowledgeEngine):
    …

    @Rule(AND(Customer(adult = True),
              Customer(fix_job = True),
              Customer(good_income = True)))
    def is_creditworthy(self):
           self.declare(Customer(creditworthy=True))

    @Rule(OR(Order(model = L("911") | L("Taycan"))))
    def can_be_produced(self):
        print("Model can be produced")
        self.declare(Warehouse(producable=True))

    @Rule(OR(Warehouse(producable = True),
             Warehouse(in_stock = True)))
    def is_available(self):
        print("Car is available")
        self.declare(Warehouse(available=True))

    @Rule(AND(Customer(creditworthy = True),
              Warehouse(available = True)))
    def sell_car(self):
        print("Car can be sold")
```

- “In general we have customer, order or warehouse information that influence our car credit process”
- “A customer can only get a car credit if he is adult, has a fix job and good income. We need this information to assess if he can pay the future credit rates of the car credit.”
- “If a customer can pay the future car credit rates and the car is available we can give the credit”
- “A car can be in stock or we have to produce it. If it can be produced or if it’s in stock the car is available for sale”
- “Due to the great success of our cars, we have currently no cars in stock. And we can only produce Taycans and 911.”

2.3 Implement the Agent

- Finally, we can add the inference code to our agent logic

```
#%% Implement scoring agent
class CreditScoringAgent():
    def inference(self):
        # We assume there is a database interface, where the agent can load the data
        engine = CreditScoring()
        engine.reset()

        # Example data from the data base
        engine.declare(Customer(adult=True, fix_job = True, good_income = True), Order(model
         = "911"))
        engine.run()

agent = CreditScoringAgent()
agent.inference()
```

- We can now add a database interface and let our agent score our customers during night time.

Classroom Case

Case

Now get more familiar with rule-based programming and add some more rules to your rule-base, for that purpose expand the rule-based agent by your own:

- Play with some other variables and check if the agent works correctly
- Implement the rules from the credit scoring example from lecture 5 to expand the rule-base
- Take a look at the Experta documentation and implement further more sophisticated rules

{ Just Keep Coding }