NARSwiki讲解系列（二）：Logic
——Higher-Order Inference (NALs-5)

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- example and demonstration (single step and multi-step)
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- Similarity, instance, property copula
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2、Higher-Order Inference (NALs-5)

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2、Higher-Order Inference (NALs-5)

NARS Wiki-   logic

- Statements ~~and Variables~~
- Revision and choice rules
- Variable, examples
- Truth function
- Basic syllogistic rules

2、Higher-Order Inference (NALs-5)

Concept

- Statements
- Term as Statements

  <(*, {Peter}, <sky --> [blue]>) ==> say>. %f; c%

Copula

- implication (==>) if then
- equivalence (<=>) if and only if

2、Higher-Order Inference (NALs-5)

	NAL-1	NAL-2	NAL-3	NAL-4
Copula	Inheritance	Similarity	Intersection	Product
		Instance	Difference	
		property		
Rules	Revision	Comparison		
	Choice	Analogy		
	Deduction	Resemblance		
	Induction			
	Abduction			
	Conversion			
	Exemplification			

2、Higher-Order Inference (NALs-5)

First-Order	Higher-Order
term	*statement*
inheritance	*implication*
similarity	*equivalence*
subject	*antecedent*
predicate	*consequent*
extension	*sufficient condition*
intension	*necessary condition*
extensional intersection	*conjunction*
intentional intersection	*disjunction*

2、Higher-Order Inference (NALs-5)

Deduction

//If robin is a type of bird then robin is a type of an

<<robin --> bird> ==> <robin --> animal>

$$\frac{M \rightarrow P(f1, c1) \qquad S \rightarrow M(f2, c2)}{S \rightarrow P(f, c)}$$

//If robin can fly then robin is a type of bird.

<<robin --> [flying]> ==> <robin --> bir

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//If robin can fly then robin is a type of animal.

//outputMustContain('<<robin --> [flying]> ==> <robin --> animal>>. %1.00;0.81%')

2、Higher-Order Inference (NALs-5)

Induction

M→P(f1, c1)
M→S(f2, c2)
S → P(f, c)

//If robin is a type of bird then robin is a type of animal.

<<robin --> bird> ==> <robin --> animal>>.

//If robin is a type of bird then robin can fly.

<<robin --> bird> ==> <robin --> [flying]>>. %0.80%

140

//I guess if robin can fly then robin is a type of animal.

//outputMustContain
('<<robin --> [flying]> ==> <robin --> animal>>. %1.00;0.39%')

//I guess if robin is a type of animal then robin can fly.

//outputMustContain
('<<robin --> animal> ==> <robin --> [flying]>>. %0.80;0.45%')

2、Higher-Order Inference (NALs-5)

Abduction

//If robin is a type of bird then robin is a type of animal.

<<robin --> bird> ==> <robin --> animal>>.

//If robin can fly then robin is probably a type of animal.

<<robin --> [flying]> ==> <robin --> animal>>. %0.

19

$P \rightarrow M (f1, c1)$

$S \rightarrow M (f2, c2)$

$\overline{S \rightarrow P (f, c)}$

//I guess if robin is a type of bird then robin can fly.

//outputMustContain

('<<robin --> bird> ==> <robin --> [flying]>>. %1.00;0.39%')

//I guess if robin can fly then robin is a type of bird.

//outputMustContain

('<<robin --> [flying]> ==> <robin --> bird>>. %0.80;0.45%')

2、Higher-Order Inference (NALs-5)

Exemplification (Inverse deduction)

//If robin can fly then robin is a type of bird.

<<robin --> [flying]> ==> <robin --> bird>>.

//If robin is a type of bird then robin is a type of anima

<<robin --> bird> ==> <robin --> animal>>.

19

//I guess if robin is a type of animal then robin can fly.

//outputMustContain
('<<robin --> animal> ==> <robin --> [flying]>>. %1.00;0.45%')

$$\frac{P \rightarrow M(f1, c1) \quad M \rightarrow S(f2, c2)}{S \rightarrow P(f, c)}$$

2、Higher-Order Inference (NALs-5)

Comparison

//If robin is a type of bird then robin is a type of anima

<<robin --> bird> ==> <robin --> animal>>.

//If robin is a type of bird then robin can fly.

<<robin --> bird> ==> <robin --> [flying]>>. %0.80%

14

//I guess robin is a type of animal if and only if robin can fly.

//outputMustContain

('<<robin --> [flying]> <=> <robin --> animal>>.
%0.80;0.45%')

M→P (f1, c1)
M→S (f2, c2)

S ↔ P (f, c)

2、Higher-Order Inference (NALs-5)

Analogy

//If robin is a type of bird then robin is a type of

<<robin --> bird> ==> <robin --> animal>>.

//Usually, robin is a type of bird if and only if rob

<<robin --> bird> <=> <robin --> [flying]>>. %0.80%

14

//If robin can fly then probably robin is a type of animal.

//outputMustContain
('<<robin --> [flying]> ==> <robin --> animal>>. %0.80;0.65%')

$$\frac{M \rightarrow P(f1, c1) \quad S \leftrightarrow M(f2, c2)}{S \rightarrow P(f, c)}$$

2、Higher-Order Inference (NALs-5)

Resemblance

//Robin is a type of animal if and only if robin is a type

M↔P(f1, c1)
S↔M(f2, c2)
S ↔ P(f, c)

<<robin --> animal> <=> <robin --> bird>>.

//Robin is a type of bird if and only if robin can fly.

<<robin --> bird> <=> <robin --> [flying]>>. %0.9%

19

//Robin is a type of animal if and only if robin can fly.

//outputMustContain(
'<<robin --> [flying]> <=> <robin --> animal>>. %0.90;0.81%')

2、Higher-Order Inference (NALs-5)

Negation

negation of a statement is a compound term with positive and negative evidence switched.

For the statement <S> %f0; c0%, its negation is <(--, S)> %f1;c1%

where negation truth function is then defined as:

F negation truth value: **f = 1 - f0, c = c0**

Contrapositive : Important to note that Law of **Contrapositive** (S => T ≡ ¬T => ¬S) is no longer true, therefore NAL-5 introduces another variant of conversion rule from NAL-1 that is from

<S1 ==> S2> %f0; c0%

NAL derives

<(--, S2) ==> (--, S1)> %f1; c1% where truth value is computed using

F conversion3: f=0, c = (1-f0)c0/(f0c0 + 1)

2、Higher-Order Inference (NALs-5)

NARS Wiki- logic

- Statements ~~and Variables~~
- Revision and choice rules
- ~~Variable, examples~~
- Truth function
- Basic syllogistic rules

2、Higher-Order Inference (NALs-5)

- **Revision and choice rules**

Revision is an inference process in which evidence from different sources is being combined and its truth value revised. Suppose there are two tasks with different truth values, for example:

<snow --> {white}>. %9/10, 10/11%

<snow --> {white}>. %3/4, 4/5%

f = [f1c1(1 - c2) + f2c2(1 - c1)] / [c1(1 - c2) + c2(1 - c1)]

c = [c1(1 - c2) + c2(1 - c1)] / [c1(1 - c2) + c2(1 - c1) + (1 - c1)(1 - c2)]

Definition 3.7. A belief in the system is a judgment in its memory that is either an element of experience K, or derived from some elements of K. At a given moment, the collection of all beliefs is called the system' s knowledge K* . The evidential base of a belief is the set of beliefs in K from which the belief is derived.

- The evidential base of an input judgment is a set containing itself,
- the evidential base of a derived conclusion is the union of the evidential bases of the premises deriving the conclusion.
- Thus it is possible that after some derivation steps, early task' serial numbers have been lost and it is exactly what the system tries to simulate, the concept of **biological memory**.

2、Higher-Order Inference (NALs-5)

- **Revision and choice rules**

- **Overlapping Evidence**
- For two tasks if they share one or more same elements within their evidential bases, their evidence is **overlapped** i.e. they do not have disjoint evidential bases.
- Ideally when combining evidence, and if some portion of evidence is present more than once, it should be subtracted from the final result,
- however since it is impossible to determine the exact amount of some portion of evidence influencing certain task this can't be done. **Therefore revision rule applies only if tasks have disjoint evidential bases that are they do not share common elements.**

2、Higher-Order Inference (NALs-5)

- **Revision and choice rules**

The choice rule is applicable in multiple scenarios.

- Two tasks are based on overlapping evidence and revision rule cannot be applied, then a choice must be made.
- Suppose there are two competing candidate answers <S --> A>. %f1, c2% and <S --> B> %f2, c2% for the question ?1>?. These candidates may be of the same or different natures and will have different truth values. Thus it is no longer appropriate to choose the answer with higher confidence.

To handle such situations truth expectation metrics are introduced.

$$e = c * (f - 0.5) + 0.5$$

The candidate with the higher truth expectation is selected by choice rule.

2、Higher-Order Inference (NALs-5)

NARS Wiki- logic

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2、Higher-Order Inference (NALs-5)

Truth function

A typical simple inference cycle in OpenNARS takes two judgments as premise and derives a judgment as a conclusion. An example looks like:

{<premise1>. %f1; c1%, <premise2>. %f2; c2%} |-- <conclusion>. %f; c%

Table C.3 The Truth-Value Functions of NAL

type	inference	name	function
local inference	revision	F_{rev}	$w^+ = w_1^+ + w_2^+$ $w^- = w_1^- + w_2^-$
	expectation	F_{exp}	$e = c(f - 0.5) + 0.5$
	decision	F_{dec}	$g = p(d - 0.5)$
immediate inference	negation	F_{neg}	$w^+ = w_1^-$ $w^- = w_1^+$
	conversion	F_{cnv}	$w^+ = and(f_1, c_1)$ $w^- = 0$
	contraposition	F_{cnt}	$w^+ = 0$ $w^- = and((not(f_1), c_1)$
strong syllogism	deduction	F_{ded}	$f = and(f_1, f_2)$ $c = and(f_1, f_2, c_1, c_2)$
	analogy	F_{ana}	$f = and(f_1, f_2)$ $c = and(f_2, c_1, c_2)$
	resemblance	F_{res}	$f = and(f_1, f_2)$ $c = and(or(f_1, f_2), c_1, c_2)$
weak syllogism	abduction	F_{abd}	$w^+ = and(f_1, f_2, c_1, c_2)$ $w = and(f_1, c_1, c_2)$
	induction	F_{ind}	$w^+ = and(f_1, f_2, c_1, c_2)$ $w = and(f_2, c_1, c_2)$
	exemplification	F_{exe}	$w^+ = and(f_1, f_2, c_1, c_2)$ $w = and(f_1, f_2, c_1, c_2)$
	comparison	F_{com}	$w^+ = and(f_1, f_2, c_1, c_2)$ $w = and(or(f_1, f_2), c_1, c_2)$
term composition	intersection	F_{int}	$f = and(f_1, f_2)$ $c = and(c_1, c_2)$
	union	F_{uni}	$f = or(f_1, f_2)$ $c = and(c_1, c_2)$
	difference	F_{dif}	$f = and(f_1, not(f_2))$ $c = and(c_1, c_2)$

2、Higher-Order Inference (NALs-5)

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2、Higher-Order Inference (NALs-5)

- Basic syllogistic rules

Table B.1 The First-Order Syllogistic Rules

$J_2 \setminus J_1$	$M \rightarrow P \langle f_1, c_1 \rangle$	$P \rightarrow M \langle f_1, c_1 \rangle$	$M \leftrightarrow P \langle f_1, c_1 \rangle$
$S \rightarrow M \langle f_2, c_2 \rangle$	$S \rightarrow P \langle F_{ded} \rangle$ $P \rightarrow S \langle F'_{exe} \rangle$	$S \rightarrow P \langle F_{abd} \rangle$ $P \rightarrow S \langle F'_{abd} \rangle$ $S \leftrightarrow P \langle F'_{com} \rangle$	$S \rightarrow P \langle F'_{ana} \rangle$
$M \rightarrow S \langle f_2, c_2 \rangle$	$S \rightarrow P \langle F_{ind} \rangle$ $P \rightarrow S \langle F'_{ind} \rangle$ $S \leftrightarrow P \langle F_{com} \rangle$	$S \rightarrow P \langle F_{exe} \rangle$ $P \rightarrow S \langle F'_{ded} \rangle$	$P \rightarrow S \langle F'_{ana} \rangle$
$S \leftrightarrow M \langle f_2, c_2 \rangle$	$S \rightarrow P \langle F_{ana} \rangle$	$P \rightarrow S \langle F_{ana} \rangle$	$S \leftrightarrow P \langle F_{res} \rangle$

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3, Conclusion

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- Negation
- **Revision and choice**
- **Basic syllogistic rules and Truth function**