HEDTOOLS

A library of Fortran subroutines / functions for modelling and simulation

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Theoretical Ecology Group

HEDTOOLS

- The AHA model includes many computational components
- HEDTOOLS was done while working on the AHA model
- General purpose procedures that can be useful for various modelling/simulation projects are isolated into the HEDTOOLS
- Purpose-developed or modified from free code on the net

HEDTOOLS

- Works with Windows and Linux
- Uses only standard Fortran elements: works with any Fortran compilers
- Intel Fortran, GNU gfortran and Oracle f95 tested and “supported”, other should also work

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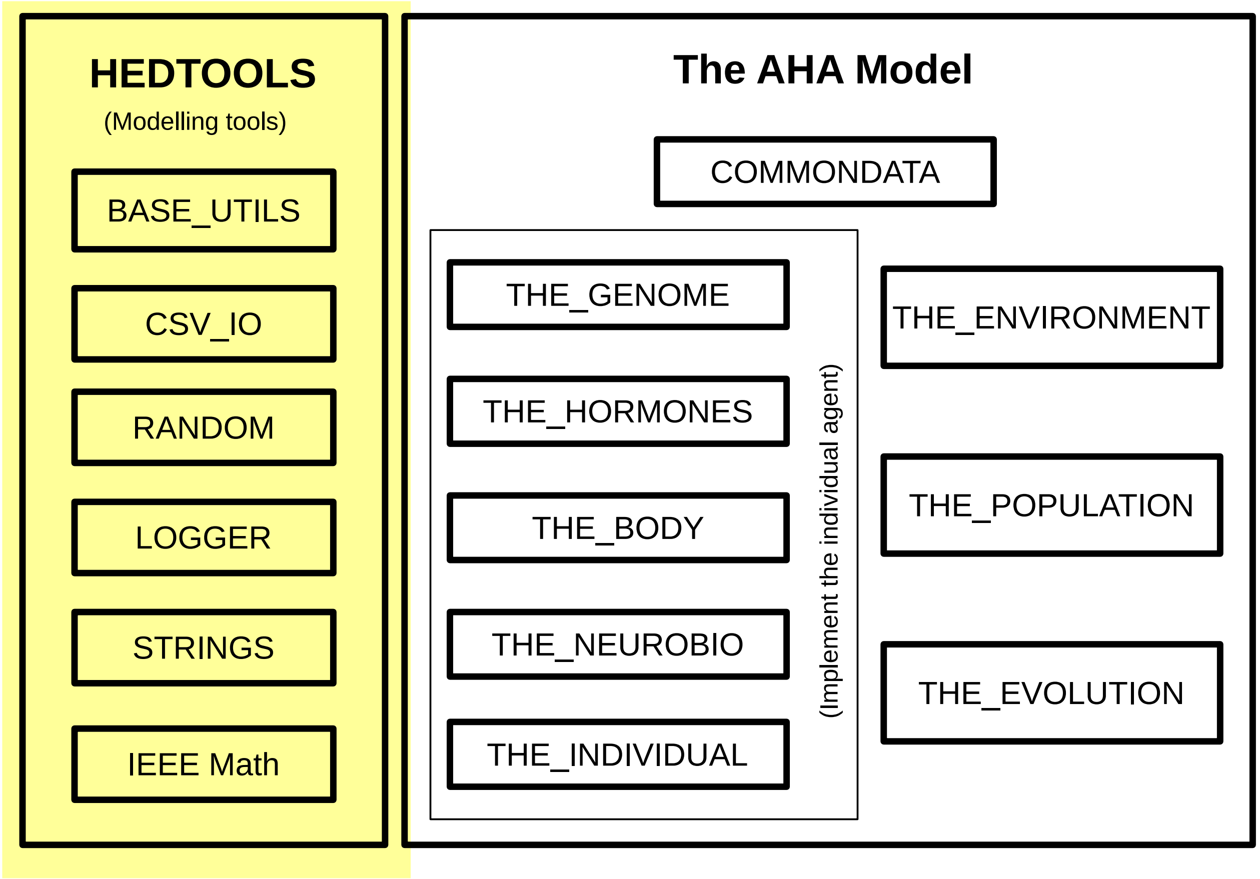
- HEDTOOL Modules



HEDTOOLS

- **BASE_UTILS – various haphazard utils**

  `TOSTR`

  `PLATFORM_IS_WINDOWS`

  Interpolation: linear and non-linear

  Array indexing

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- TOSTR

```
STRING = TOSTR(12)
```

```
print *, ">", TOSTR(3.1415926), "<"
```

```
print *, ">", TOSTR(3.1415926,"(f4.2)"), "<"
```

```
>>3.14<<
```

```
out_file = "File_" // TOSTR(10, 10000) // ".txt"
```

```
File_00010.txt
```

- Runtime platform

```
if ( PLATFORM_IS_WINDOWS() ) print *, "Run on Windows."
```

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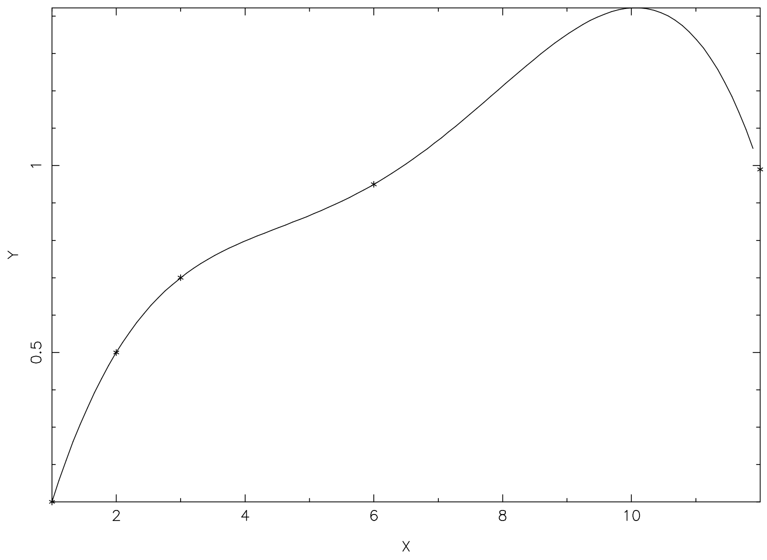
- Interpolation:
  LINTERPOL, DDPINTERPOL,INTERP_LINEAR, INTERP_LAGRANGE

```
DDPINTERPOL( [1.,2.,3.,6.,12.], [0.1, 0.5, 0.7, 0.95,
0.99], 0.2, IERR )
```

Divided difference polynomial



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- Array indexing: `ARRAY_INDEX ARRAY_RANK`

```
! Calculate index array for vector X
call ARRAY_INDEX(X, index_array)

! To get the vector X sorted, use this index array:
print *, X(index_array)
```

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- **CSV_IO – Writing and reading *comma separated value* (CSV) files**
- Many subroutines
- Low-level routines and high-level routines (write a whole matrix)
- Advantages of CSV: human-readable and easy to import into any spreadsheet or stats package.

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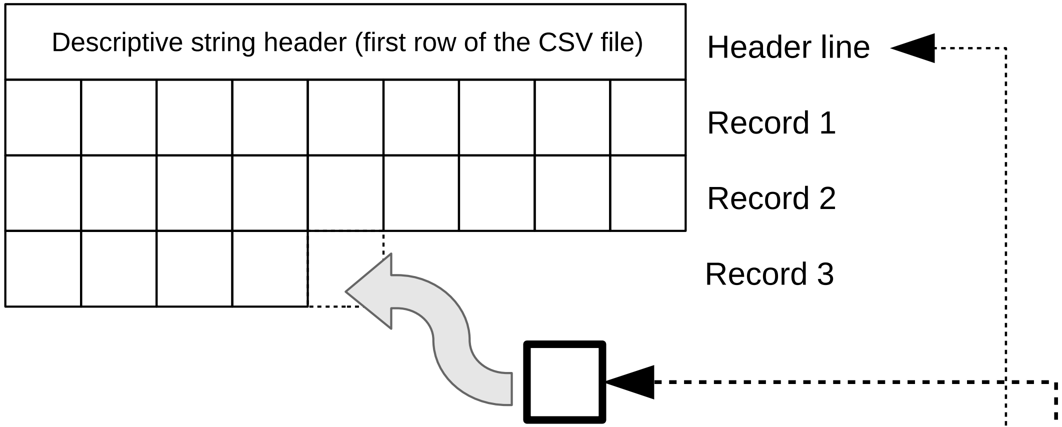
- Low-level routines



```
CSV_OPEN_WRITE - physically open CSV file for writing;
CSV_HEADER_WRITE - physically write optional descriptive header
do ... - start loop_1 cycle over rows / records
    do ... - start loop_2 cycle within the record over column values
        CSV_RECORD_APPEND – append data values to the
            current record / row of the data file
    end do ... - end loop 2
    CSV_RECORD_WRITE - physically write record to disk, go to next record
end do ... - end loop 2
CSV_CLOSE - physically closes the CSV data file.
```

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- High-level routines

```
call CSV_MATRIX_WRITE(matrix=Matr, csv_file_name=filename,                &
                      csv_file_status=errorflag,                          &
                      colnames=["VAR_01", ("VAR_" // TOSTR(i,10),i=2,6)] )
```

```
call CSV_MATRIX_WRITE( reshape(                                           &
                          [generation_one%individual%fitness,             &
                           generation_one%individual%person_number],      &
                          [POPSIZE, 2]),                                  &
                          "output_data_file.csv",                         &
                          ["FITNESS ","ID_NUMBER"]                        &
                           )
```

```
Matr = CSV_MATRIX_READ(filename, errorflag)
```

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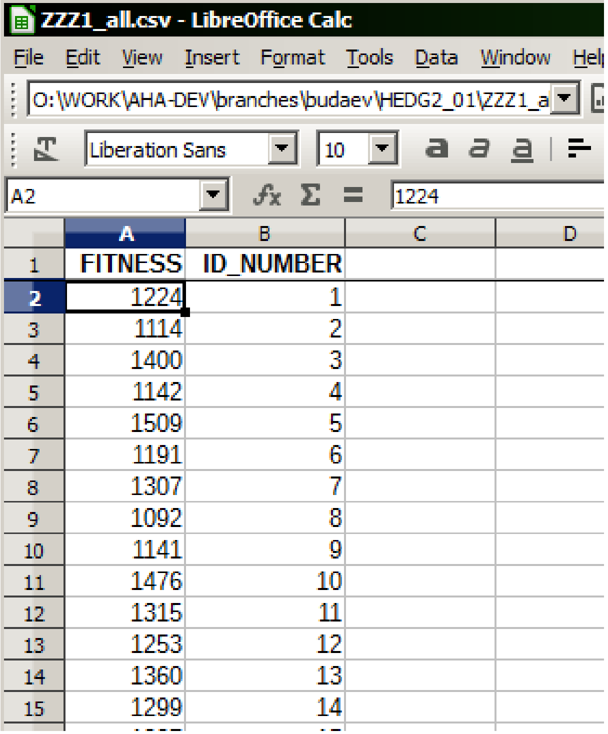
```
call CSV_MATRIX_WRITE( reshape(                                           &
                             [generation_one%individual%fitness,          &
                              generation_one%individual%person_number],   &
                             [POPSIZE, 2]),                               &
                             "ZZZ1_all.csv",                              &
                             ["FITNESS ","ID_NUMBER"]                     &
                              )
```


ZZZ1_all.csv - LibreOffice Calc
File
Edit
View
Insert
Format
Tools
Data
Window
Help
O:\WORK\AHA-DEV\branches\budaev\HEDG2_01\ZZZ1_a
Liberation Sans
10
A2
1224

	A	B	C	D
1	FITNESS	ID_NUMBER		
2	1224	1		
3	1114	2		
4	1400	3		
5	1142	4		
6	1509	5		
7	1191	6		
8	1307	7		
9	1092	8		
10	1141	9		
11	1476	10		
12	1315	11		
13	1253	12		
14	1360	13		
15	1299	14		

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- **BASE_RANDOM – working with random numbers**
- RANDOM_SEED_INIT – parallel-safe seed
- Random integer: `ipos = RAND_I(1, 100)`
- Random number function:

```
if ( RAND() < ga_mutationrate ) then
```

- Gaussian random numbers:

```
ga_len = RNORM(100.,10.)
```

- Random permutation, arrays of random numbers etc.

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- Random permutation

```
print *, PERMUTE_RANDOM(10)      ! Produces: 7, 4, 5, 10, 3, 9, 2, 1, 8, 6
print *, X(PERMUTE_RANDOM(size(X)))  ! array X in random order
```

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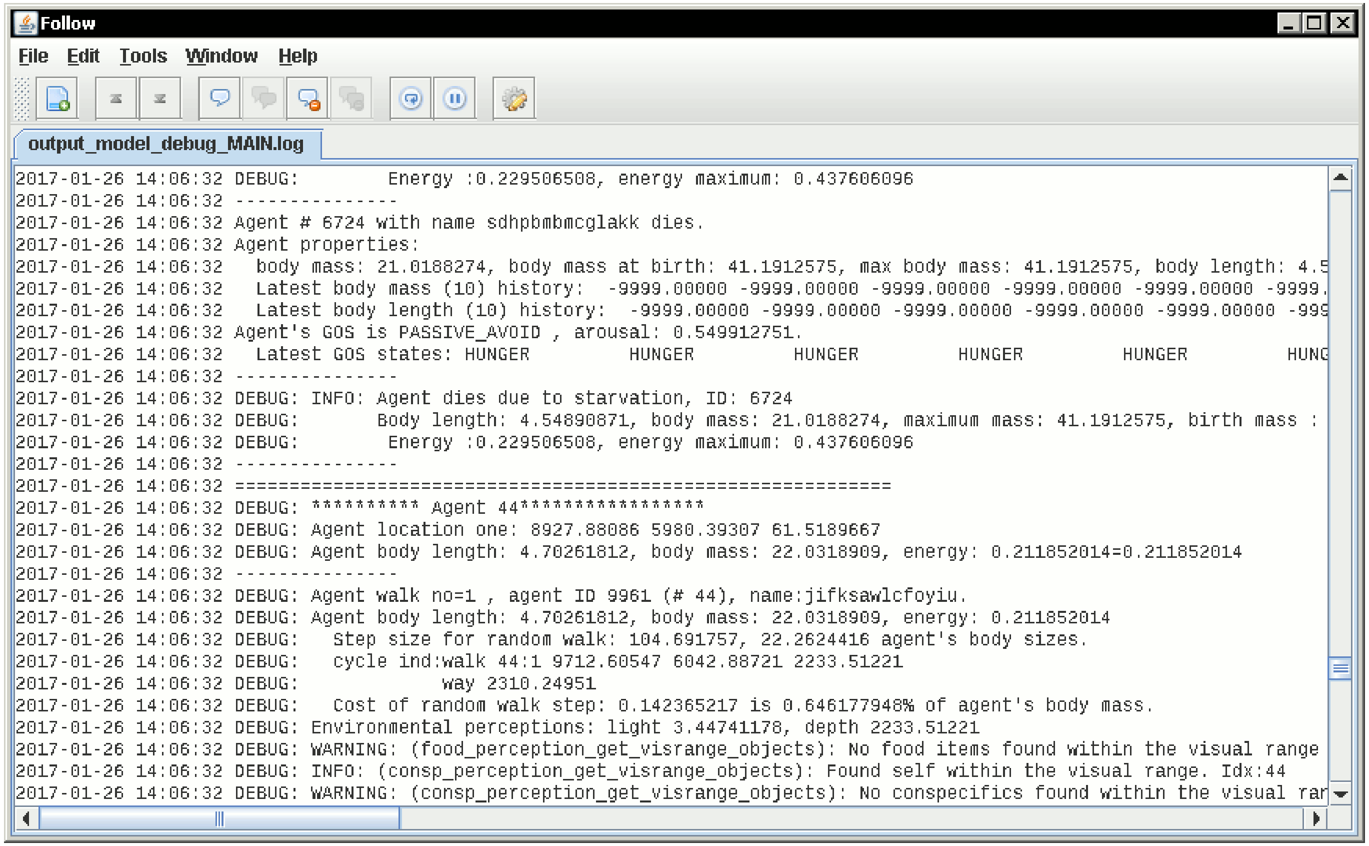
- Other modules:
  LOGGER – producing log file outputs, String manipulation module, IEEE math module



```
2017-01-26 14:06:32 DEBUG:        Energy :0.229506508, energy maximum: 0.437606096
2017-01-26 14:06:32 ---------------
2017-01-26 14:06:32 Agent # 6724 with name sdhpbmbmcglakk dies.
2017-01-26 14:06:32 Agent properties:
2017-01-26 14:06:32   body mass: 21.0188274, body mass at birth: 41.1912575, max body mass: 41.1912575, body length: 4.5
2017-01-26 14:06:32   Latest body mass (10) history:  -9999.00000 -9999.00000 -9999.00000 -9999.00000 -9999.00000 -9999.
2017-01-26 14:06:32   Latest body length (10) history:  -9999.00000 -9999.00000 -9999.00000 -9999.00000 -9999.00000 -999
2017-01-26 14:06:32 Agent's GOS is PASSIVE_AVOID , arousal: 0.549912751.
2017-01-26 14:06:32   Latest GOS states: HUNGER         HUNGER         HUNGER         HUNGER         HUNGER         HUNG
2017-01-26 14:06:32 ---------------
2017-01-26 14:06:32 DEBUG: INFO: Agent dies due to starvation, ID: 6724
2017-01-26 14:06:32 DEBUG:       Body length: 4.54890871, body mass: 21.0188274, maximum mass: 41.1912575, birth mass :
2017-01-26 14:06:32 DEBUG:        Energy :0.229506508, energy maximum: 0.437606096
2017-01-26 14:06:32 ---------------
2017-01-26 14:06:32 ============================================================
2017-01-26 14:06:32 DEBUG: ********** Agent 44*****************
2017-01-26 14:06:32 DEBUG: Agent location one: 8927.88086 5980.39307 61.5189667
2017-01-26 14:06:32 DEBUG: Agent body length: 4.70261812, body mass: 22.0318909, energy: 0.211852014=0.211852014
2017-01-26 14:06:32 ---------------
2017-01-26 14:06:32 DEBUG: Agent walk no=1 , agent ID 9961 (# 44), name:jifksawlcfoyiu.
2017-01-26 14:06:32 DEBUG: Agent body length: 4.70261812, body mass: 22.0318909, energy: 0.211852014
2017-01-26 14:06:32 DEBUG:   Step size for random walk: 104.691757, 22.2624416 agent's body sizes.
2017-01-26 14:06:32 DEBUG:   cycle ind:walk 44:1 9712.60547 6042.88721 2233.51221
2017-01-26 14:06:32 DEBUG:             way 2310.24951
2017-01-26 14:06:32 DEBUG:   Cost of random walk step: 0.142365217 is 0.646177948% of agent's body mass.
2017-01-26 14:06:32 DEBUG: Environmental perceptions: light 3.44741178, depth 2233.51221
2017-01-26 14:06:32 DEBUG: WARNING: (food_perception_get_visrange_objects): No food items found within the visual range
2017-01-26 14:06:32 DEBUG: INFO: (consp_perception_get_visrange_objects): Found self within the visual range. Idx:44
2017-01-26 14:06:32 DEBUG: WARNING: (consp_perception_get_visrange_objects): No conspecifics found within the visual rar
```

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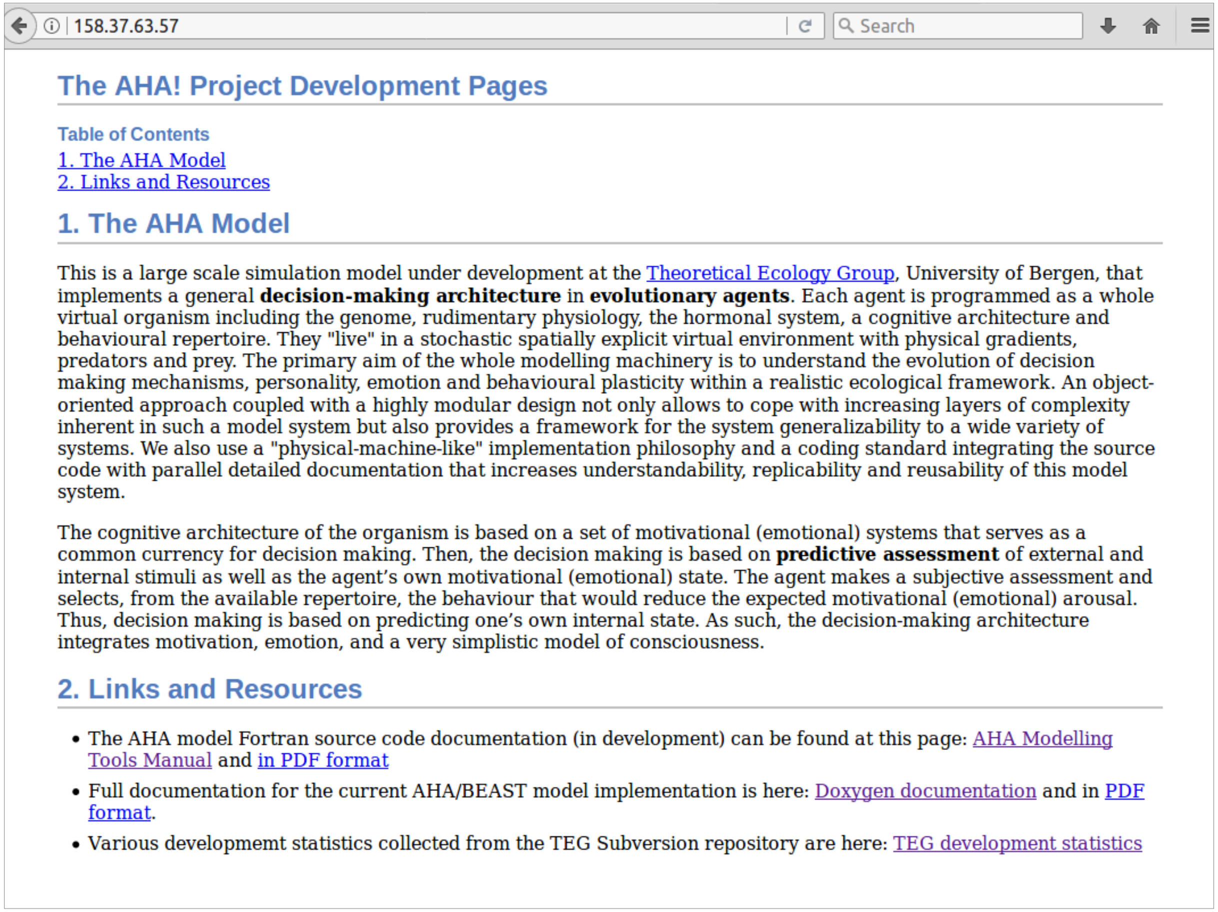
- The AHA! Project Development Pages http://158.37.63.57/



The AHA! Project Development Pages

Table of Contents

1. The AHA Model

This is a large scale simulation model under development at the Theoretical Ecology Group, University of Bergen, that implements a general **decision-making architecture** in **evolutionary agents**. Each agent is programmed as a whole virtual organism including the genome, rudimentary physiology, the hormonal system, a cognitive architecture and behavioural repertoire. They "live" in a stochastic spatially explicit virtual environment with physical gradients, predators and prey. The primary aim of the whole modelling machinery is to understand the evolution of decision making mechanisms, personality, emotion and behavioural plasticity within a realistic ecological framework. An object-oriented approach coupled with a highly modular design not only allows to cope with increasing layers of complexity inherent in such a model system but also provides a framework for the system generalizability to a wide variety of systems. We also use a "physical-machine-like" implementation philosophy and a coding standard integrating the source code with parallel detailed documentation that increases understandability, replicability and reusability of this model system.

The cognitive architecture of the organism is based on a set of motivational (emotional) systems that serves as a common currency for decision making. Then, the decision making is based on **predictive assessment** of external and internal stimuli as well as the agent's own motivational (emotional) state. The agent makes a subjective assessment and selects, from the available repertoire, the behaviour that would reduce the expected motivational (emotional) arousal. Thus, decision making is based on predicting one's own internal state. As such, the decision-making architecture integrates motivation, emotion, and a very simplistic model of consciousness.

2. Links and Resources

- The AHA model Fortran source code documentation (in development) can be found at this page: AHA Modelling Tools Manual and in PDF format
- Full documentation for the current AHA/BEAST model implementation is here: Doxygen documentation and in PDF format.
- Various developmemt statistics collected from the TEG Subversion repository are here: TEG development statistics

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- HEDTOOLS source code available at the **TEG Subversion** repository:

  stable branch:
  https://svn.uib.no/aha-fortran/trunk/HEDTOOLS

  development branch:
  https://svn.uib.no/aha-fortran/branches/budaev/HEDTOOLS

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```
!!   - this\%reprfact_decrement_estrogen.
!!   .
!! At this stage, the state of the agent is not changed. Only the state of
!! `this` behaviour changes, and it will be later passed to modify the
!! agent.
call this%do_this( this_agent = this_agent,                              &
                   p_reproduction=this_agent%probability_reproduction(),  &
                   is_reproduce = is_reproduce)

!> Also log the fake perceptions along with the agent's sex if running in
!! the DEBUG mode.
call LOG_DBG( LTAG_INFO // "Agent sex is: " // this_agent%label_sex() //  &
              "(is male: " // TOSTR(this_agent%is_male()) // "); " //     &
              "testosterone decrement: " //                               &
              TOSTR(this%reprfact_decrement_testosterone) //              &
              "; estrogen decrement: " //                                 &
              TOSTR(this%reprfact_decrement_estrogen), PROCNAME, MODNAME )

!> #### Step 2: Change the agent ####
!> Second, **change the agent's state** as a consequence of reproduction.
!> (1) Decrease the sex steroids level following the reproduction. This
!! is different in males and females: testosterone is decreased in males
!! and estrogen, in females.
if ( this_agent%is_male() ) then
  call this_agent%testosterone_set(value_set=this_agent%testosterone_get()&
          - this%reprfact_decrement_testosterone, update_history=.TRUE.)
else
  call this_agent%estrogen_set(value_set=this_agent%estrogen_get()         &
          - this%reprfact_decrement_estrogen, update_history=.TRUE.)
end if

!> (2) Decrement the body mass as a                  eproduction. This
!! body mass decrement constitutes                    of reproduction.
!! The updated body mass (after sub             st) has already been
!! calculated as `body_mass_after`.
call this_agent%set_mass( value_set                   ,                   &
                          update_his
!> Additionally, also call the `the_bod             on::set_length()` method
!! to update the body length history stack. However, the value_set
!! parameter here is just the current value. This fake re-setting of the
!! body length is done to keep both mass and length synchronised in their
!! history stack arrays (there is no procedure for only updating history).
call this_agent%set_length( value_set = this_agent%get_length(),          &
                            update_history = .TRUE. )

!> After resetting the body mass, update energy reserves of the agent, that
!! depend on both the length and the mass.
```

Thanks!!!