Parameter Estimation for Human Trust in Information Sources

Mark Hoogendoorn, S. Waqar Jaffry, and Jan Treur

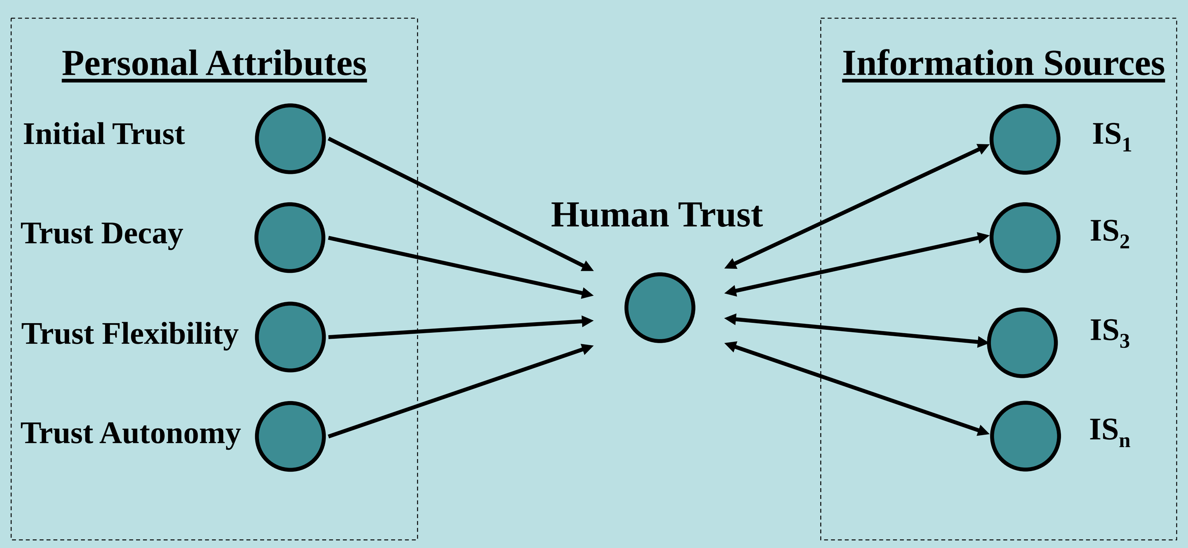
Vrije Universiteit Amsterdam, Department of Artificial Intelligence, De Boelelaan 1081a, 1081 HV Amsterdam, the Netherlands, {mhoogen, swjaffry, treur}@few.vu.nl

PROBLEM

- The behavior of a computational human trust model crucially depend on the specific values of different parameters related to human personality.
- How these parameters can be tuned to a specific individual?

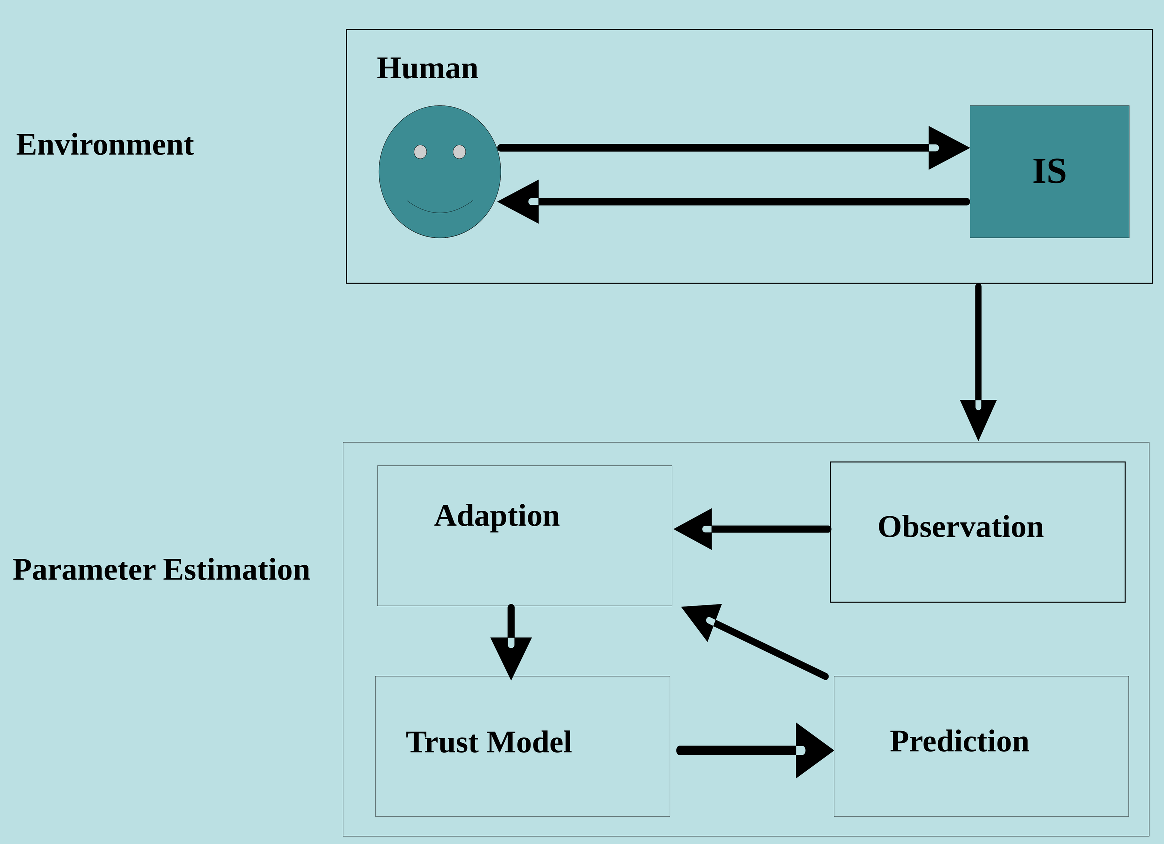
EXAMPLE MODEL [1]

- Human Personality Attribute
  - Initial bias (initial trust)
  - Memory (trust decay)
  - Experience Frugality (trust flexibility)
  - Dependence of Information Sources (trust autonomy)
- At each time step human requests one of the competitive information source with high trust value.



Dynamic Relationships in the Human Trust Model on Competitive Information Sources

APPROACH



Parameter Estimation for Human Trust in Information Sources

ACCURACY

Accuracy = Correct Predictions / Observed Behaviors

METHODS

EXHAUSTIVE SEARCH METHOD

- On each observation entire attribute search space is explored to find the vector of parameter settings with maximum accuracy.
- Guarantees the optimal solution.

BISECTION SEARCH METHOD

- On each observation entire attribute search space is explored by halving the intervals for the parameter values to find the vector of parameter settings with maximum accuracy.
- Does not guarantee the optimal solution.

EXTENDED BISECTION SEARCH METHOD

- Find parameter setting with maximum accuracy as in Bisection Search Method
- Store parameters in list of solutions for future use.
- Compare the accuracy of current parameter setting with all known solutions in the list.
- Does not guarantee the optimal solution.

STIMULATED ANNEALING METHOD

- Search the parameter with maximum accuracy in the neighborhood of initial parameters selected randomly.
- Neighborhood for search depends on computational budget and accuracy of parameter setting

  Neighborhood = ComputationalBudgetLeft * (1 – Accuracy)

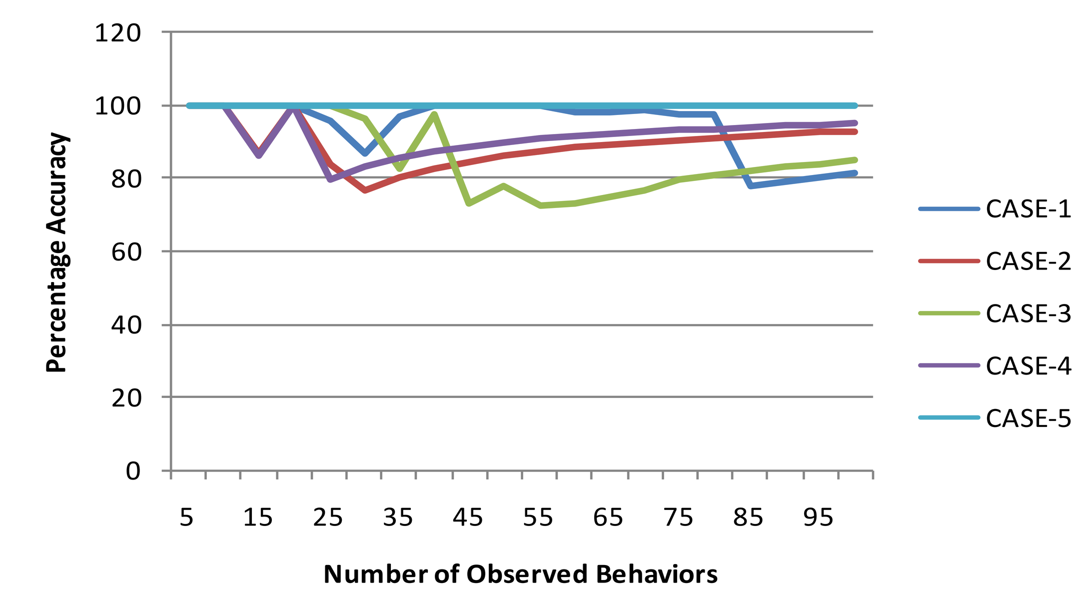
TIME COMPLEXITY

Methods	Complexity
Exhaustive Search	$O((10)^{\alpha\tau} NB^2)$
Bisection Search	$O(\alpha\tau NB^2)$
Extended Bisection Search	$O(\alpha\tau NB^2)$
Simulated Annealing	$O(CNB^2)$
α = No. of Parameters, τ = Precision of Estimation, N = No. of Information Sources, B = Observed Behaviors, C = Computational Budget (for stimulated annealing)	

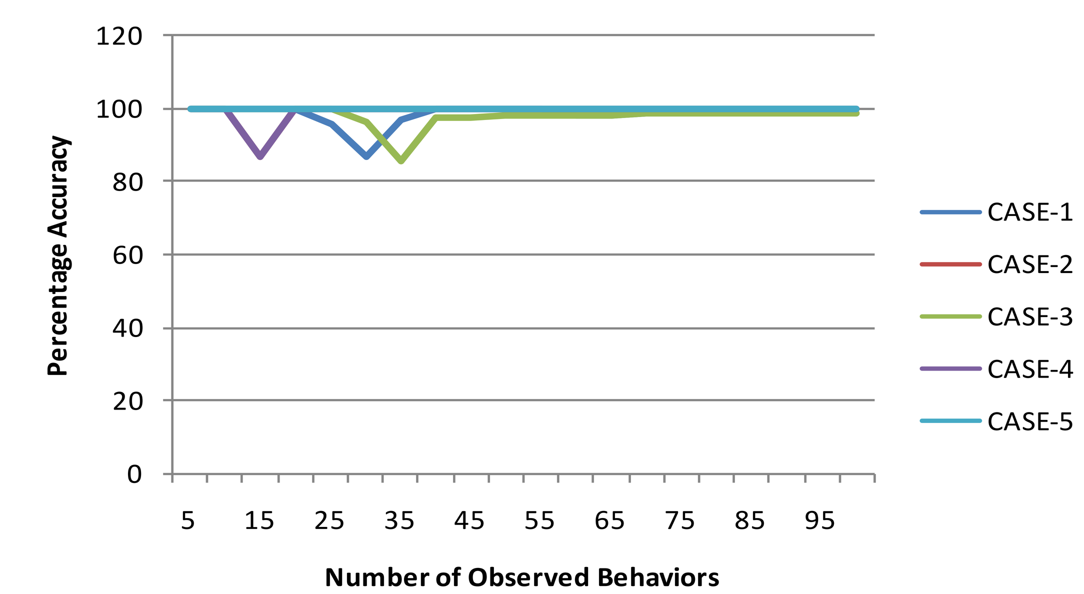
SIMULATION AND RESULTS

Experimental Configurations for generating Human Behavior

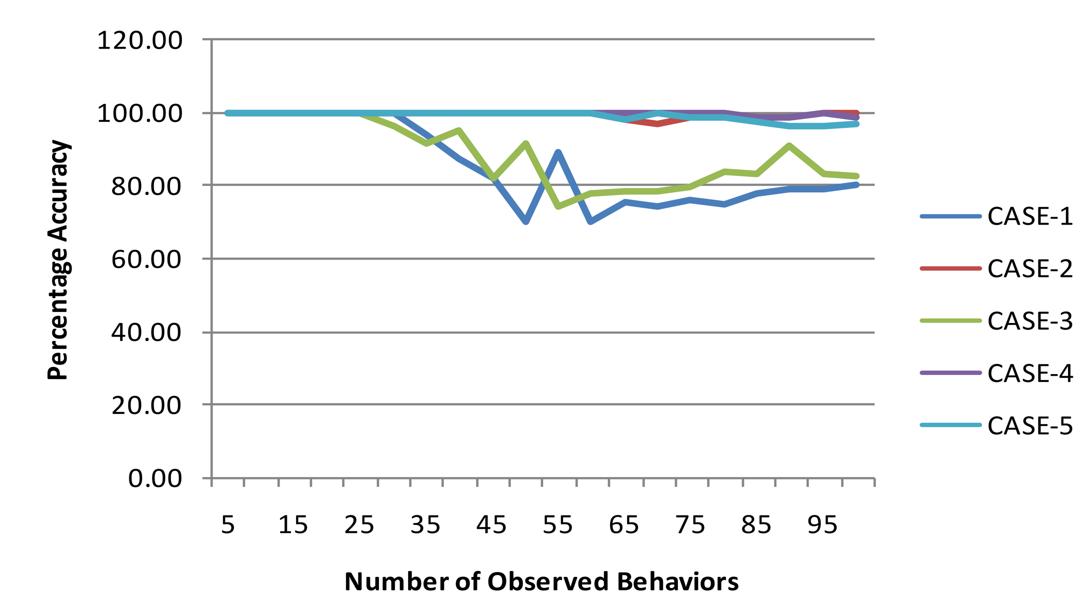
Case	1	2	3	4	5
No. of Parameters	3	3	3	3	3
Precision (digits)	2	2	2	2	2
Information Sources	3	3	3	3	3
IS_1,IS_2,IS_3 Responses	1,-1,-1	1,-1,-1	1,-1,-1	1,-1,-1	1,-1,-1
Observed Behaviors	100	100	100	100	100
Trust Decay	0.01	0.01	0.01	0.25	0.01
Trust Flexibility	0.75	0.75	0.25	0.75	0.75
Trust Autonomy	0.25	0.25	0.25	0.25	0.75
Human Initial Trust on Sources IS_1, IS_2, IS_3	0.00, 0.15, 0.30	0.00, 0.05, 0.10	0.00, 0.05, 0.10	0.00, 0.05, 0.10	0.00, 0.05, 0.10



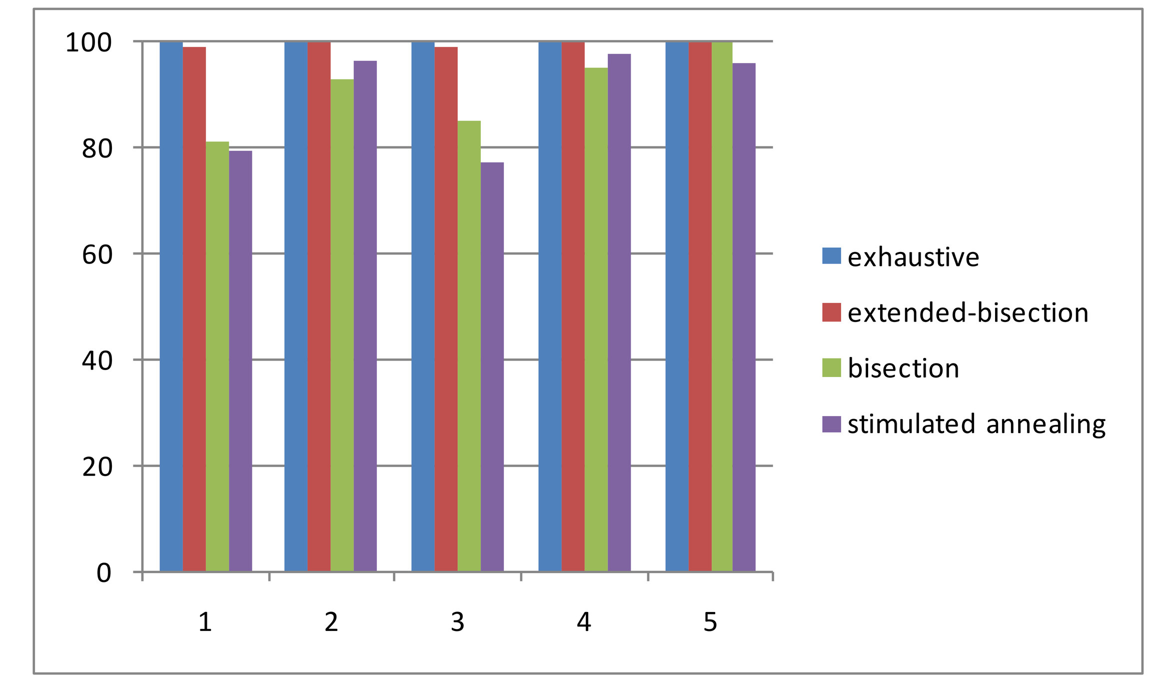
Accuracy of Bisection Search Method



Accuracy of Extended Bisection Search Method



Maximum Percentage Accuracy of Stimulated Annealing



Accuracy of All Methods in Case 1, 2, 3, 4, and 5

FORMAL ANALYSIS

P1(trace, λ): Information reduces possible solutions

If at time point t the set of observed behaviors is of size n and the number of solutions found is p1, then if at a later point in time t2 the set of observed behaviors is larger (i.e. m > n), then the number of solutions found p2 is less than or equal to p1 * λ.

Formally:

∀ t:time, n:integer, p1:integer

[state(γ, t) |= number_observed_behaviors(n) & state(γ, t) |= number_solutions(p1)] ⇒ [∀ t2:time, m:integer, p2:integer [[t2 > t & m > n & state(γ, t2) |= number_observed_behaviors(m) & state(γ, t2) |= number_solutions(p2)] ⇒ p2 ≤ p1 * λ]]]

CONCLUSIONS

- Computation time of the exhaustive search scales up worst, whereas the Simulated Annealing approach scales up best.
- Exhaustive search finds the most accurate settings, whereas Simulated Annealing sometimes only comes up with poor solutions.
- The bisection, and extended bisection are right in the middle: They do have a higher accuracy and are computationally less expensive.
- The choice of which method to use ultimately depends on the domain.

REFERENCE

[1] Hoogendoorn, M., Jaffry, S.W., and Treur, J., "Modeling Dynamics of Relative Trust of Competitive Information Agents", In: Klusch, M., Pechoucek, M., Polleres, A. (eds.), Proceedings of the 12th International Workshop on Cooperative Information Agents, CIA'08. LNAI, vol. 5180. Springer, 2008, pp. 55-70.