Leo de Penning

Neural Symbolic Cognitive Agents

Training and Assessment in Simulators

TNO | Knowledge for business

TNO Virtual Instruction Platform (VIP)

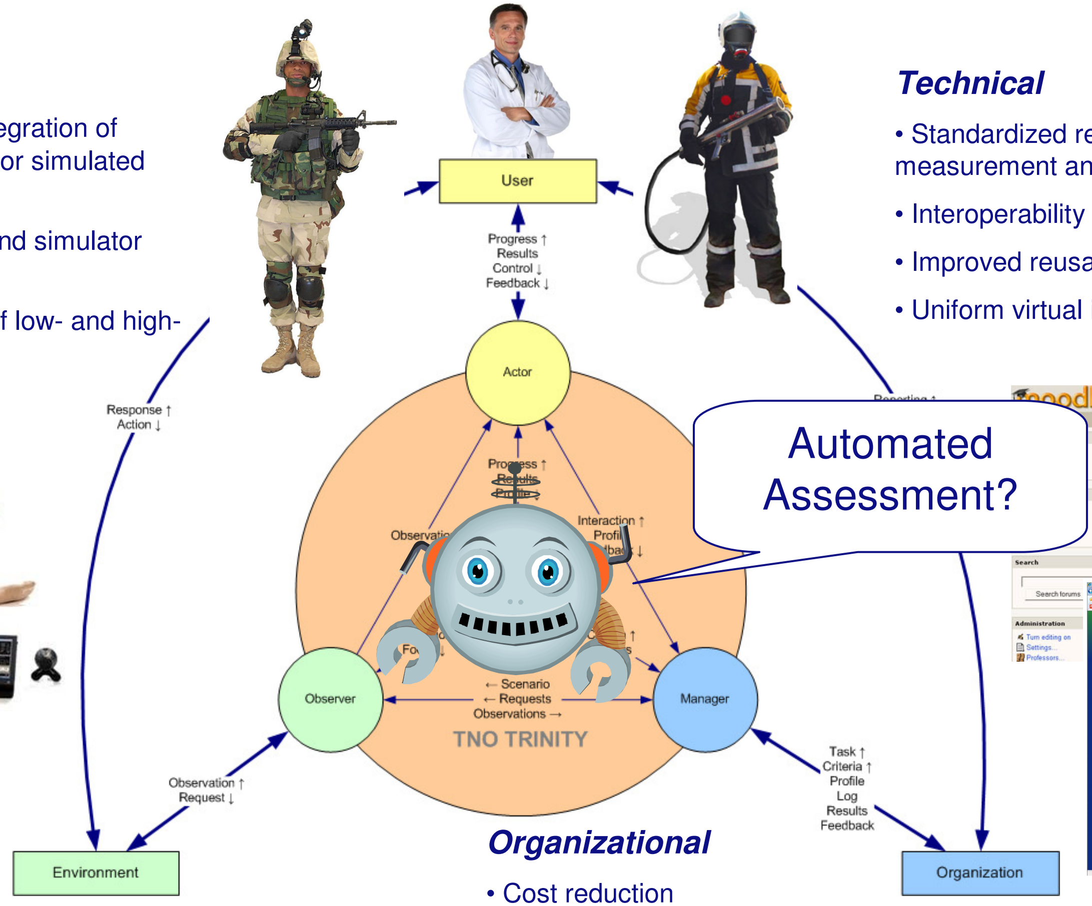
Integrating Users, Environments and Organizations for Training, Assessment and Research

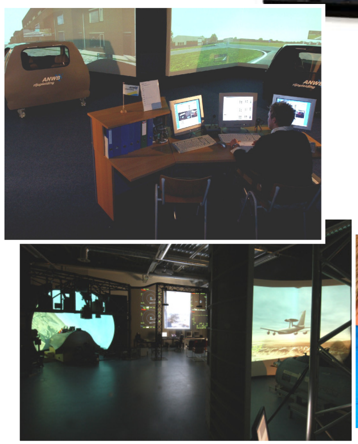
Pedagogical

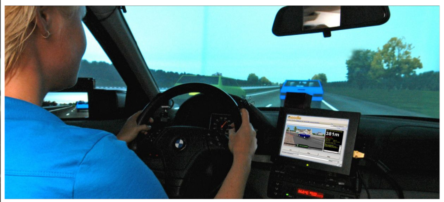
- Simple and seamless integration of learning with CBT and live or simulated environments
- Standardization of CBT and simulator didactics
- Automated assessment of low- and high-order skills

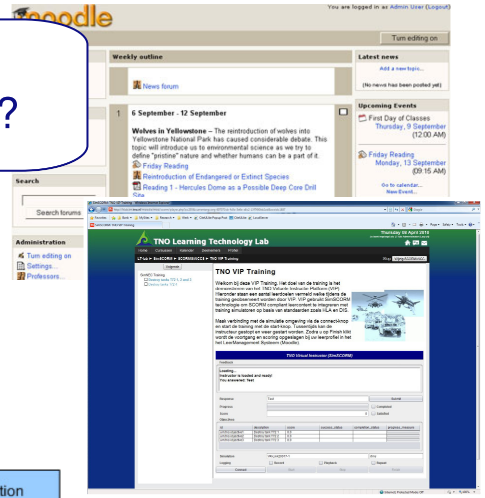
Technical

- Standardized real-time performance measurement and administration
- Interoperability of learning content
- Improved reusability
- Uniform virtual instruction environment



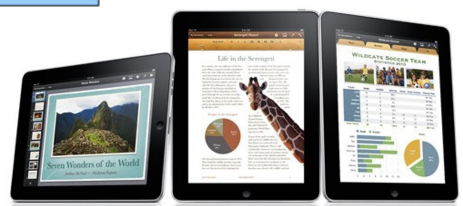






Organizational

- Cost reduction
- Content development independent of training environment
- Standardized and reusable learning content and results
- Learning anytime, anywhere



Automated Assessment!

The ingredients

1. Start with an agent with access to the simulator, task and user

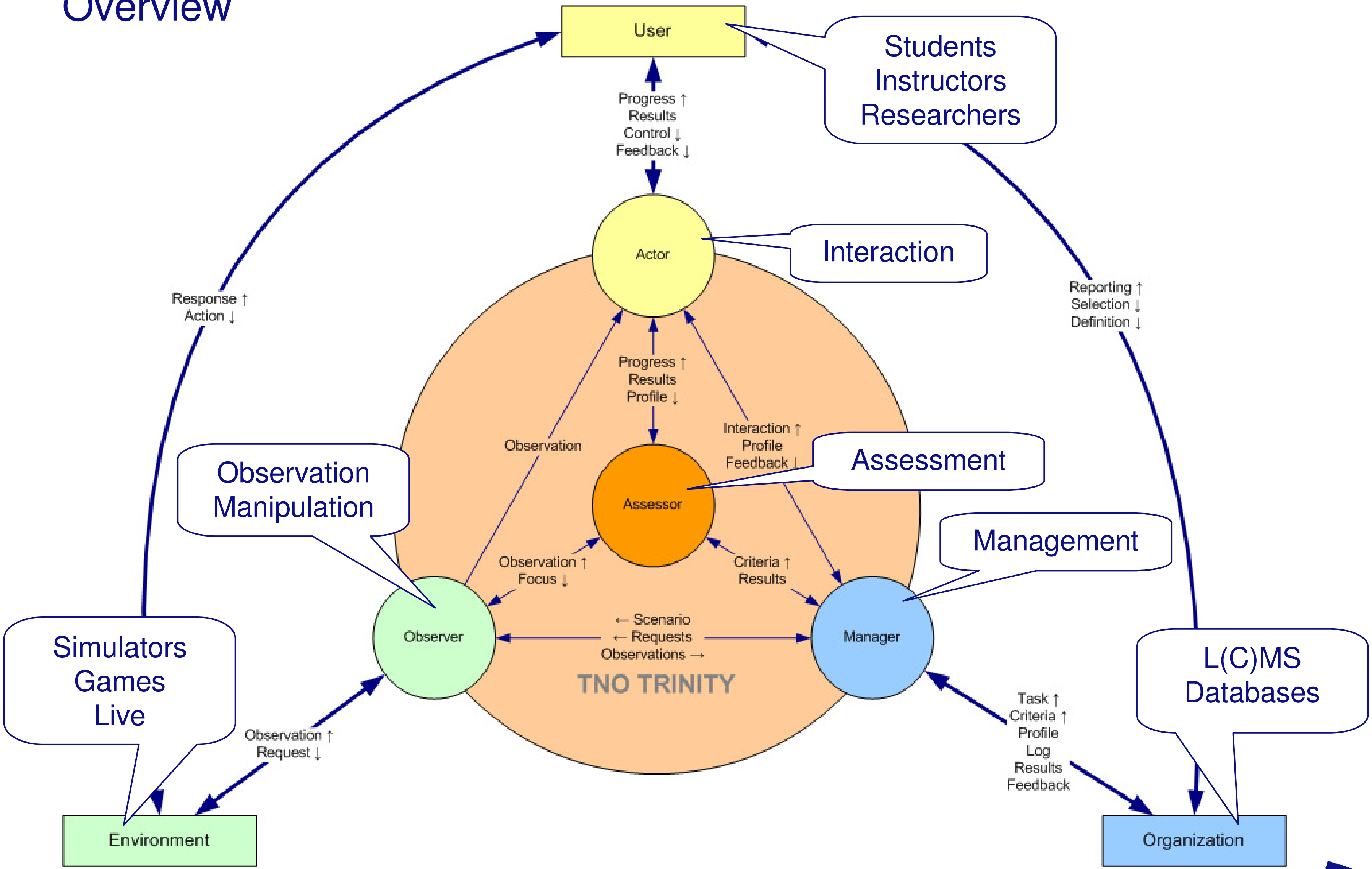
2. Add a Recurrent Temporal Restricted Boltzmann Machine (RTRBM)

3. Use a Continuous Stochastic input layer to handle continuous data

4. Encode and extract knowledge to/from RTRBM using its energy function

Multi-Agent Virtual Instruction Platform

Overview



Virtual Instruction Platform
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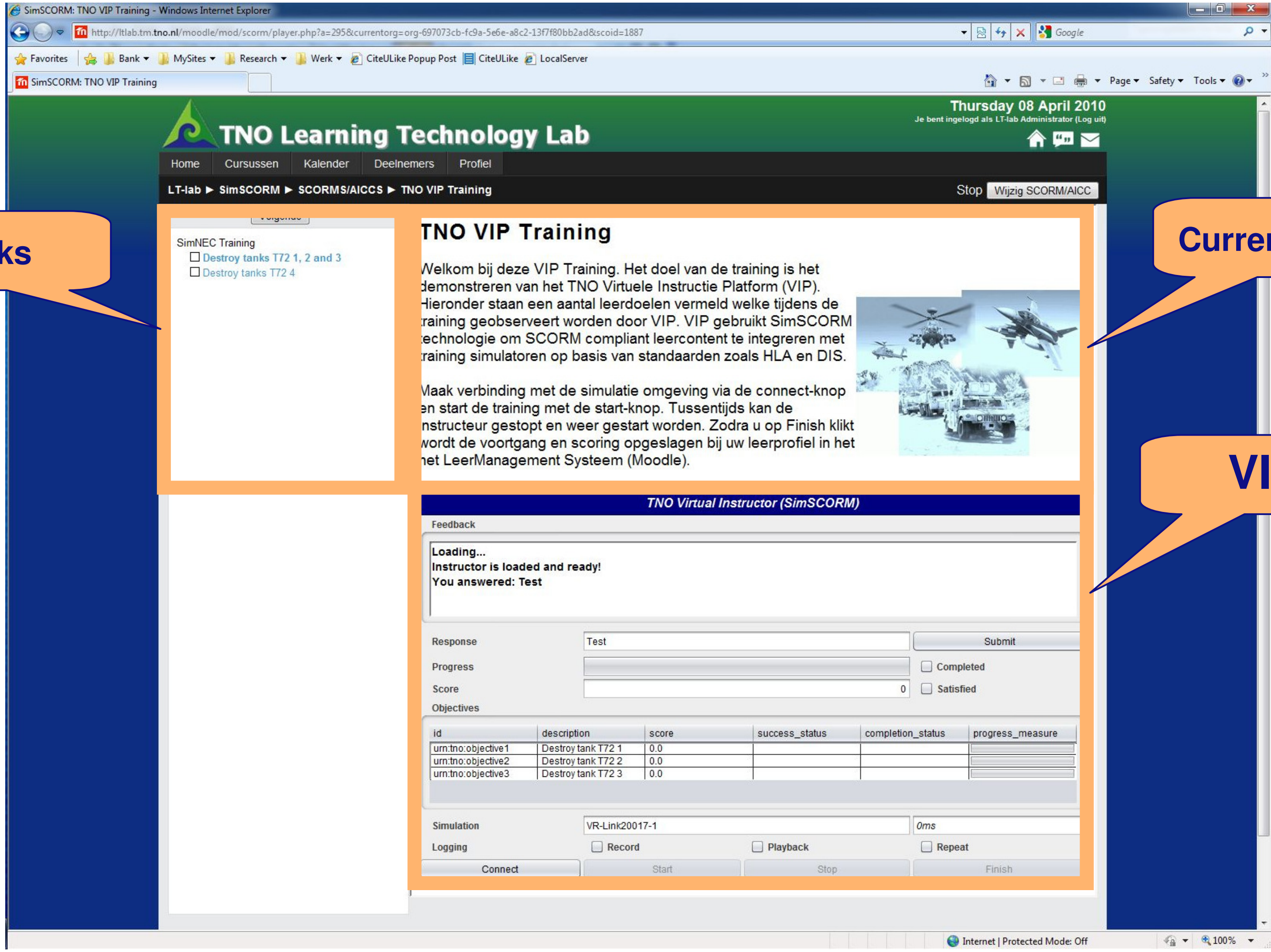
Virtual Instruction Platform

Presentation

Tasks

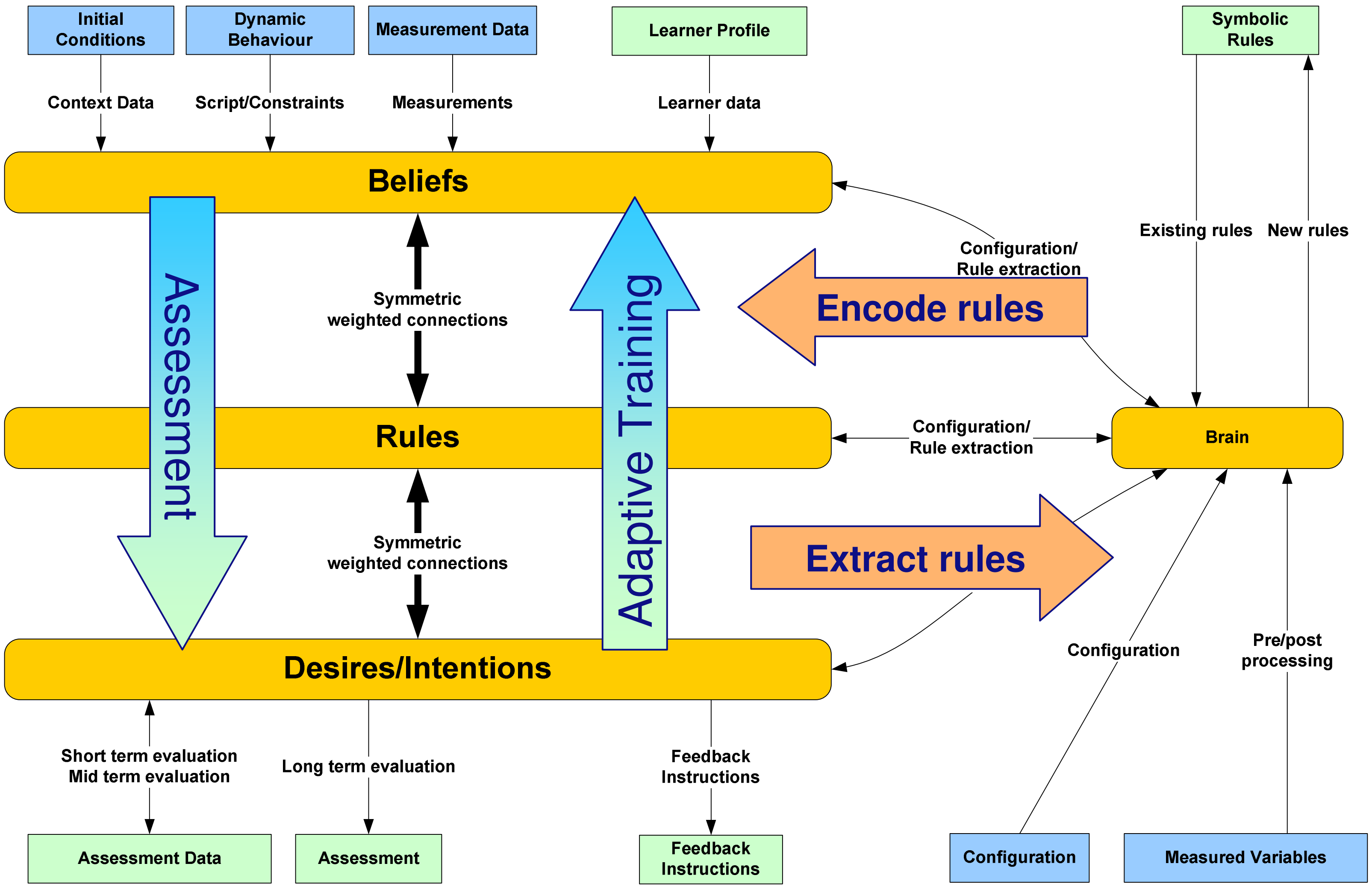
Current Task

VIP



Neural Symbolic Cognitive Agent

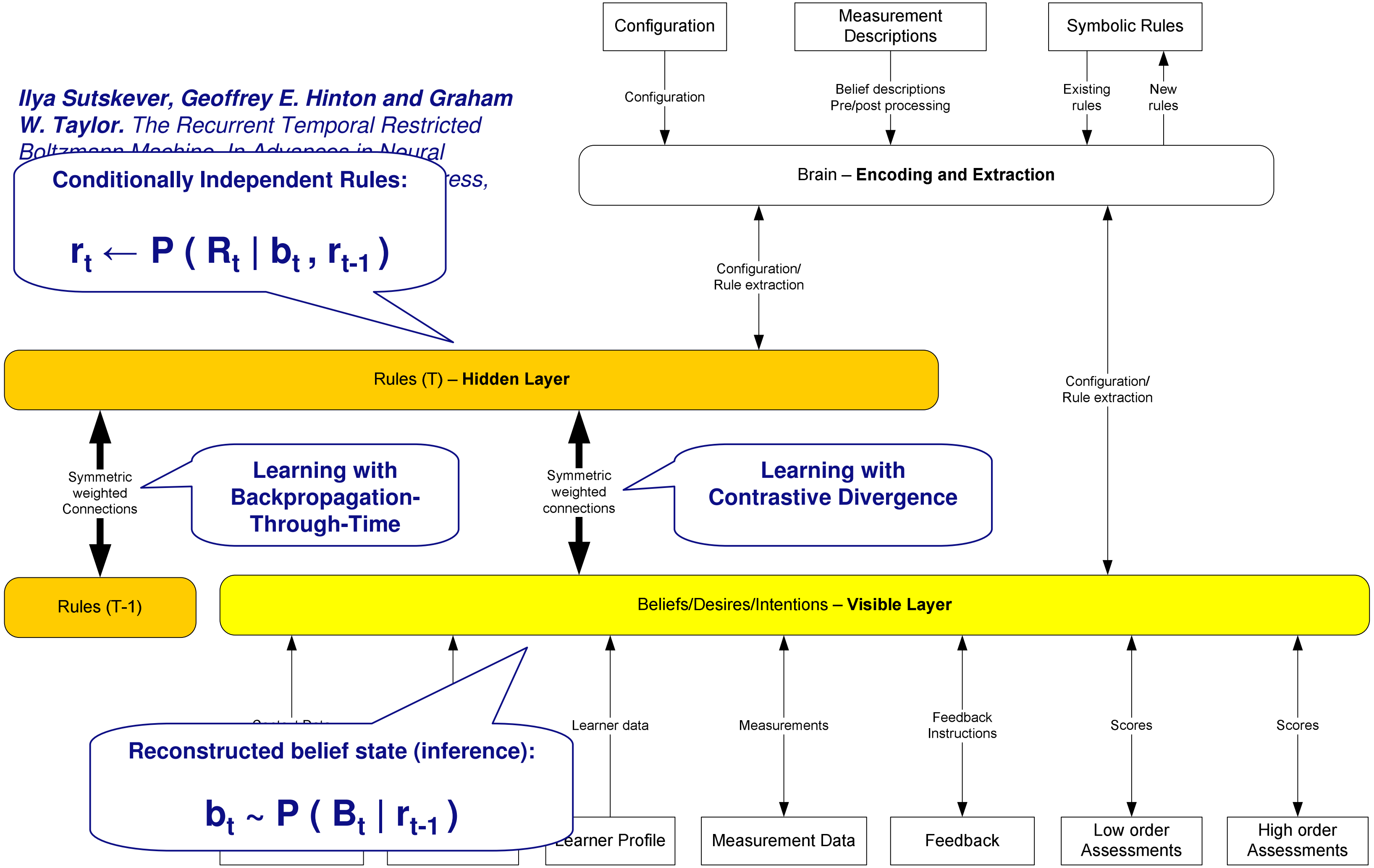
Architecture



Neural Symbolic Cognitive Agent

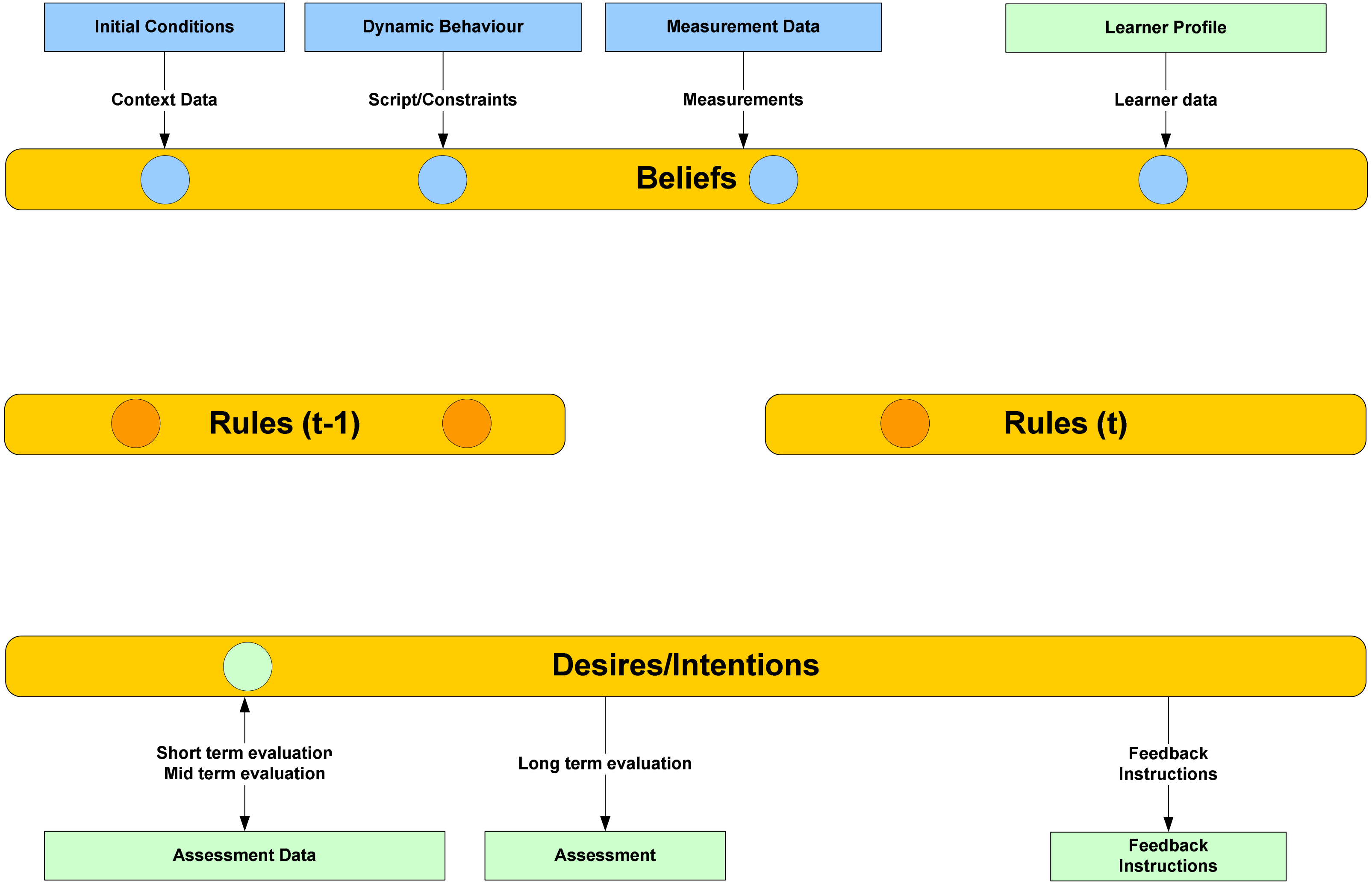
Recurrent Temporal Restricted Boltzmann Machine (RTRBM)

Ilya Sutskever, Geoffrey E. Hinton and Graham W. Taylor. *The Recurrent Temporal Restricted Boltzmann Machine. In Advances in Neural ... ress,*



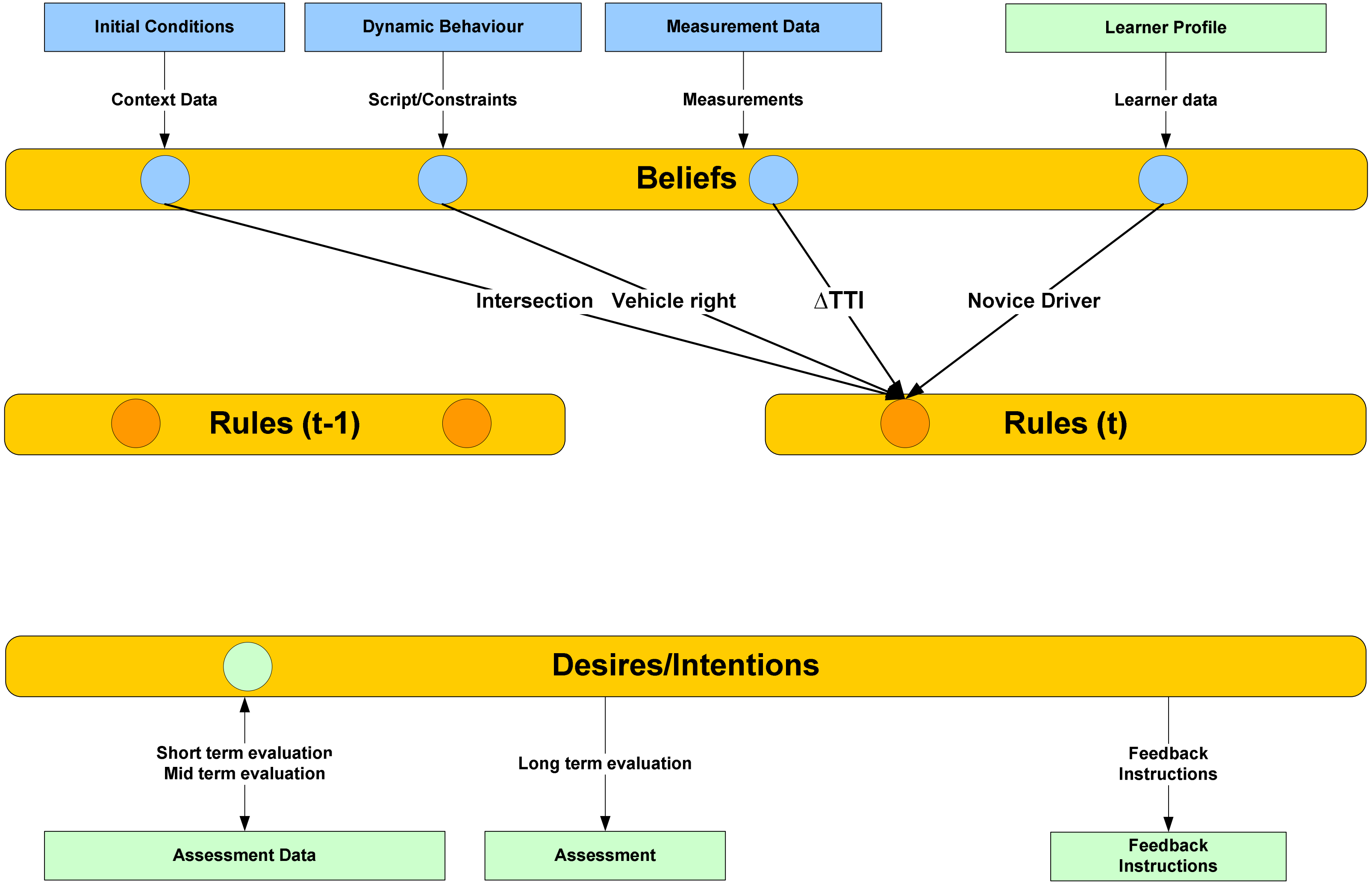
Neural Symbolic Cognitive Agent

Automated Assessment



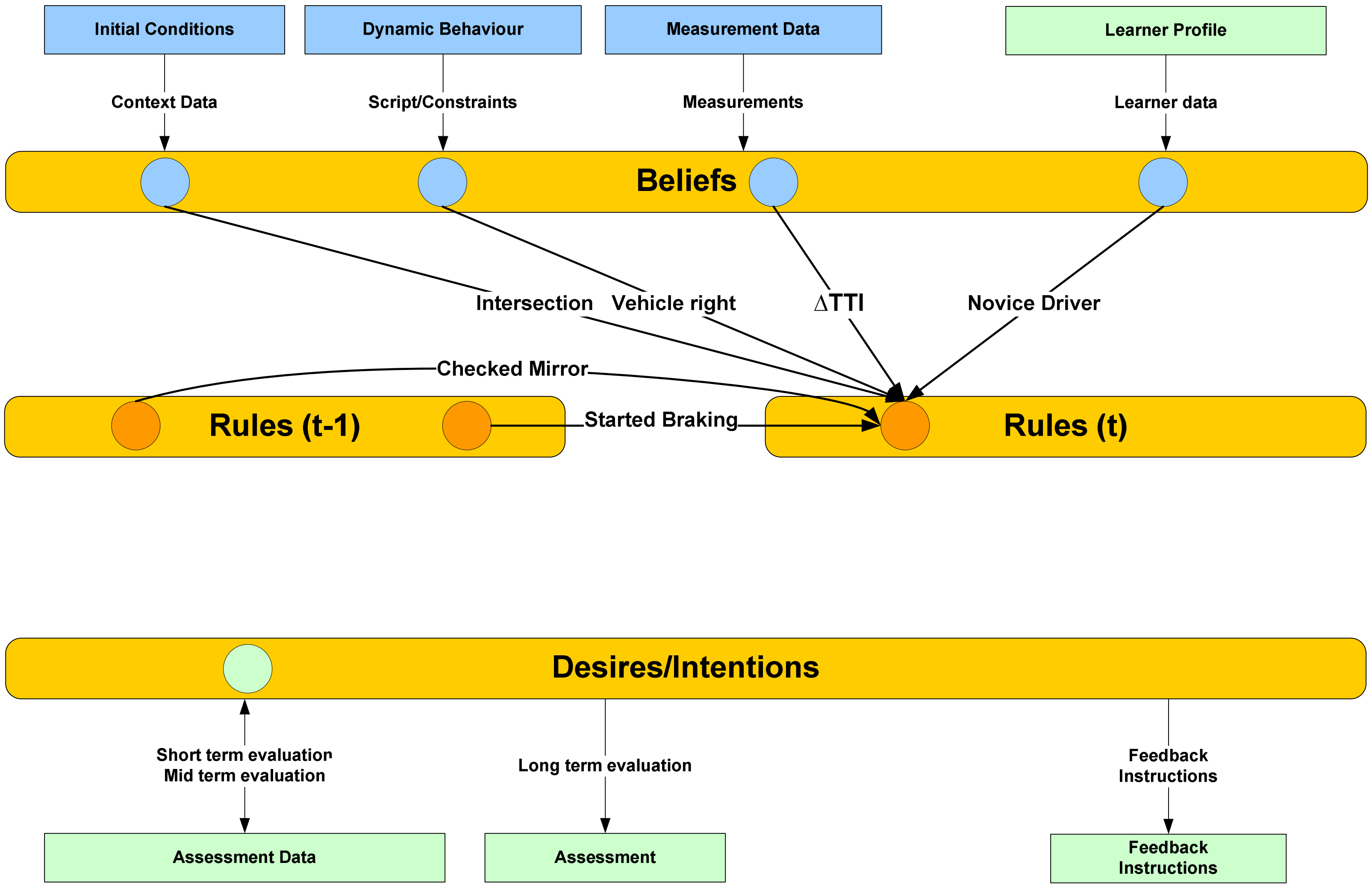
Neural Symbolic Cognitive Agent

Automated Assessment



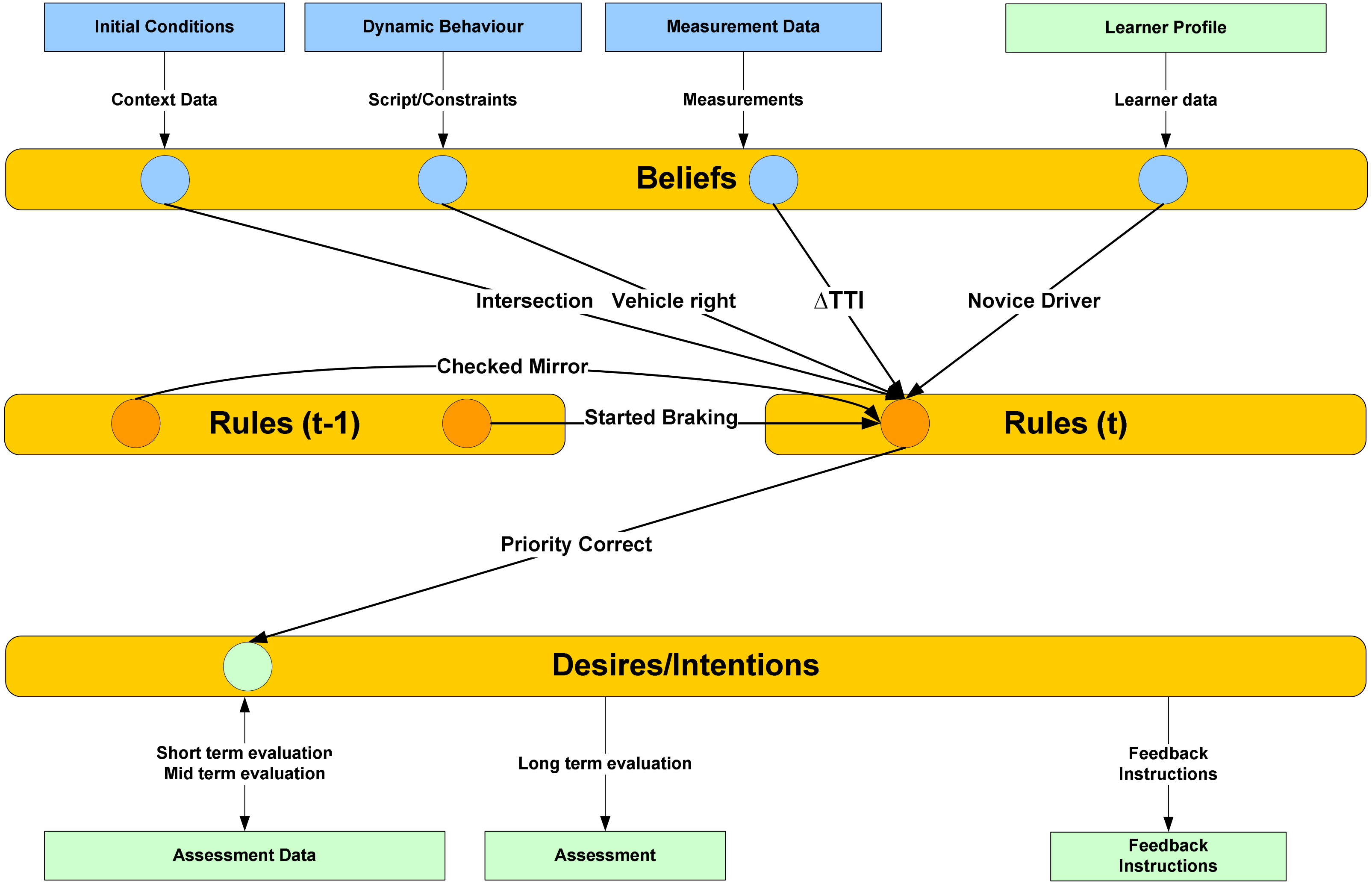
Neural Symbolic Cognitive Agent

Automated Assessment



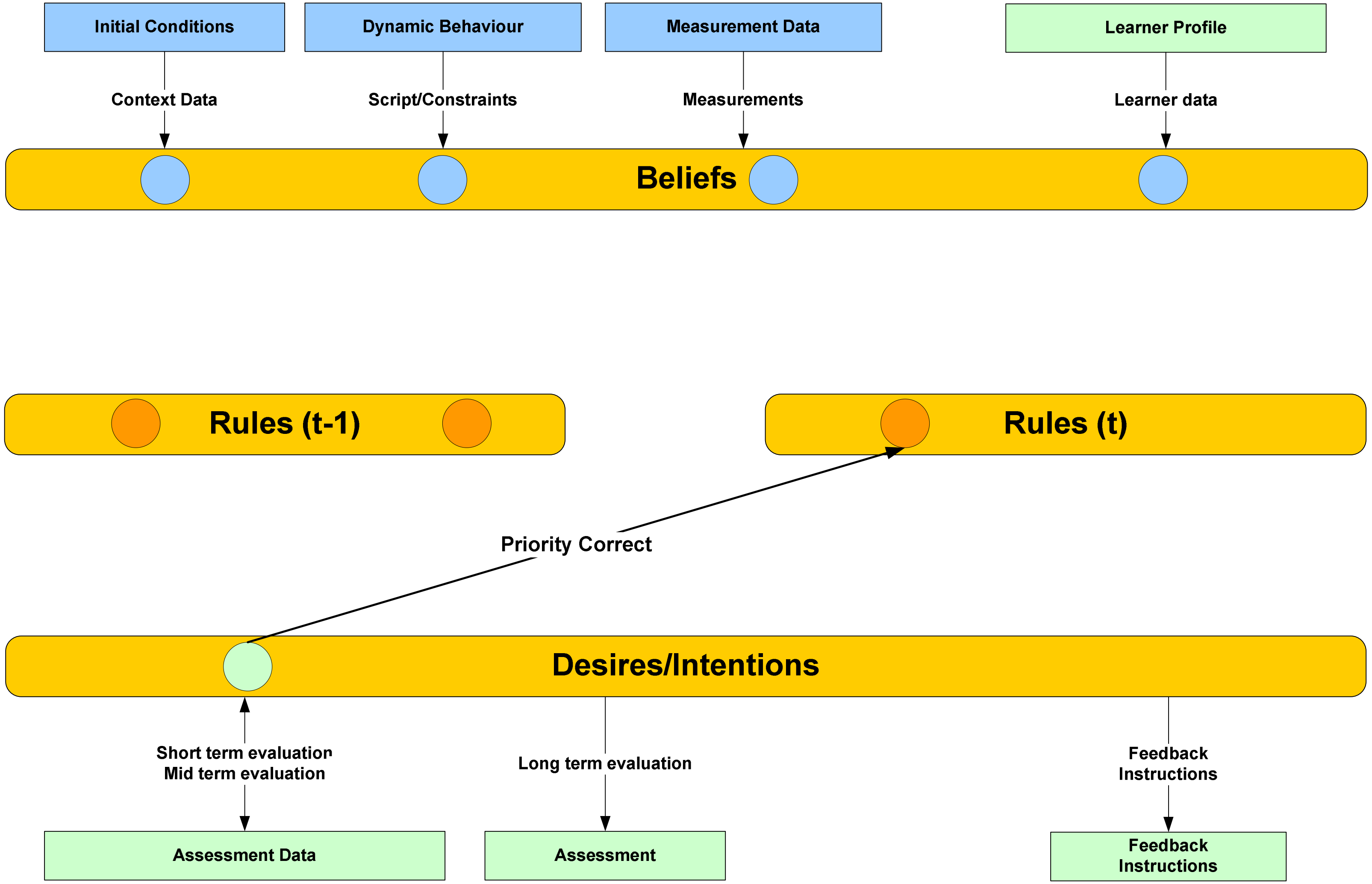
Neural Symbolic Cognitive Agent

Automated Assessment



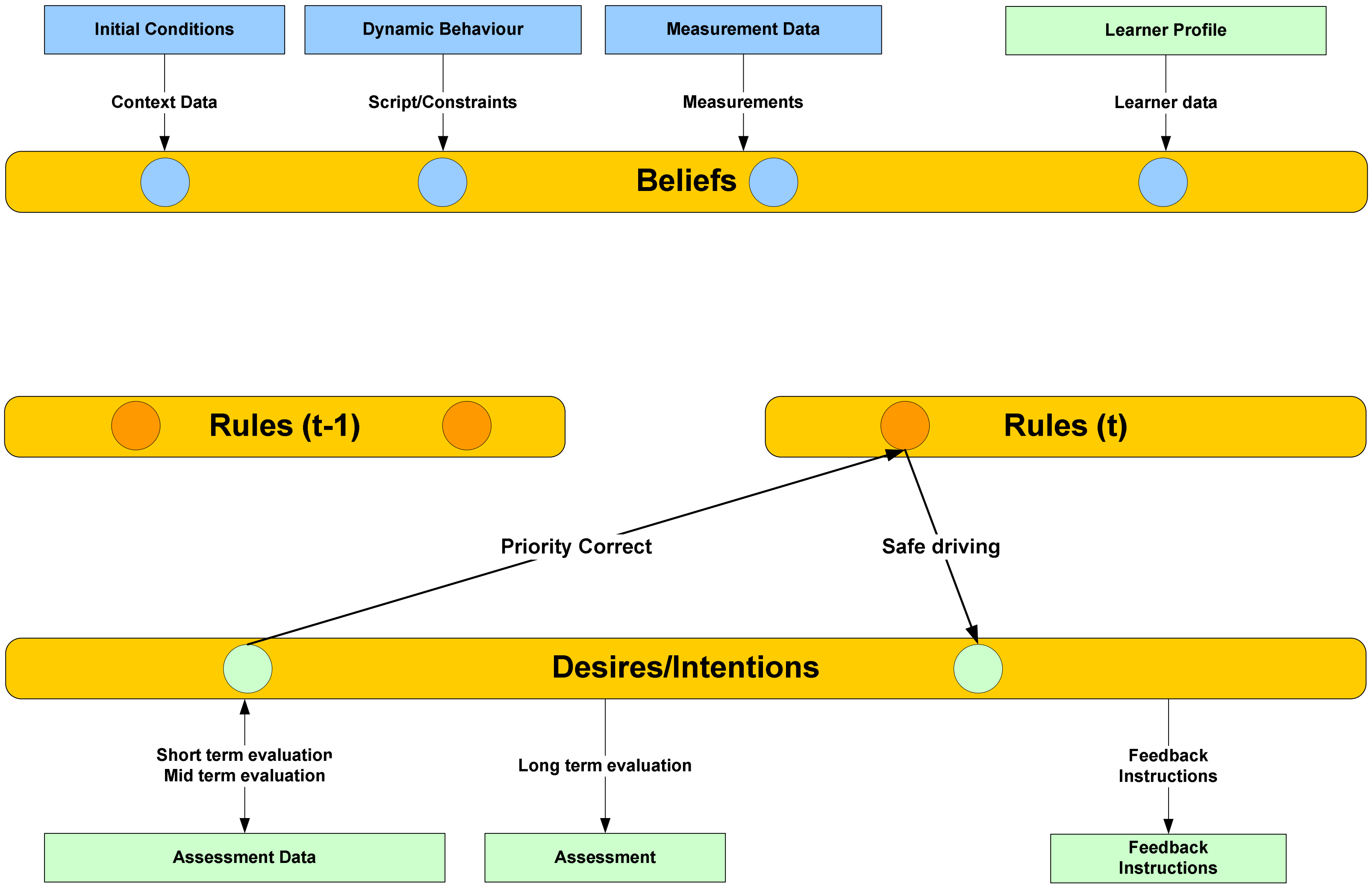
Neural Symbolic Cognitive Agent

Automated Assessment



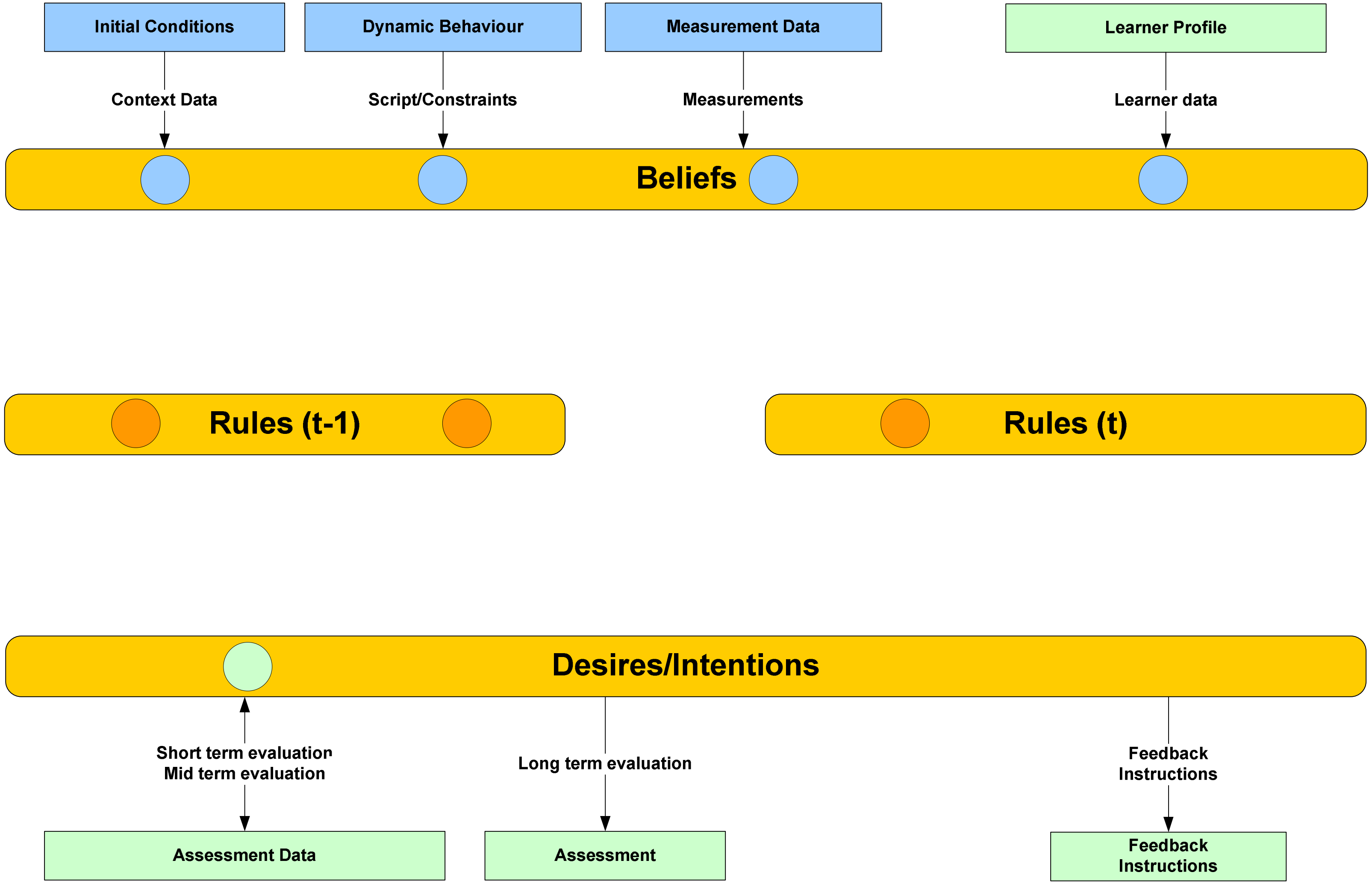
Neural Symbolic Cognitive Agent

Automated Assessment



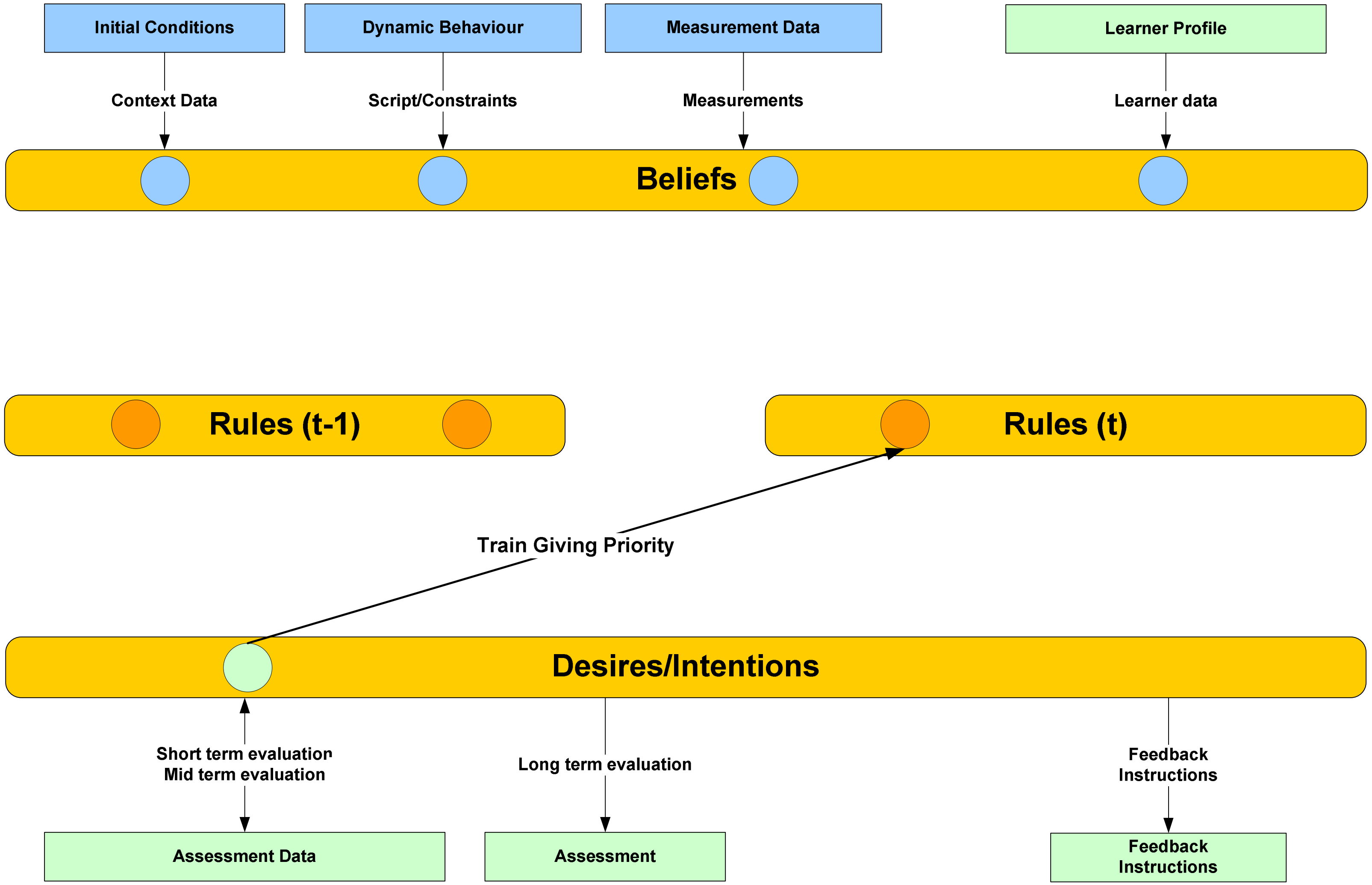
Neural Symbolic Cognitive Agent

Adaptive Training with Cognitive-based Feedback



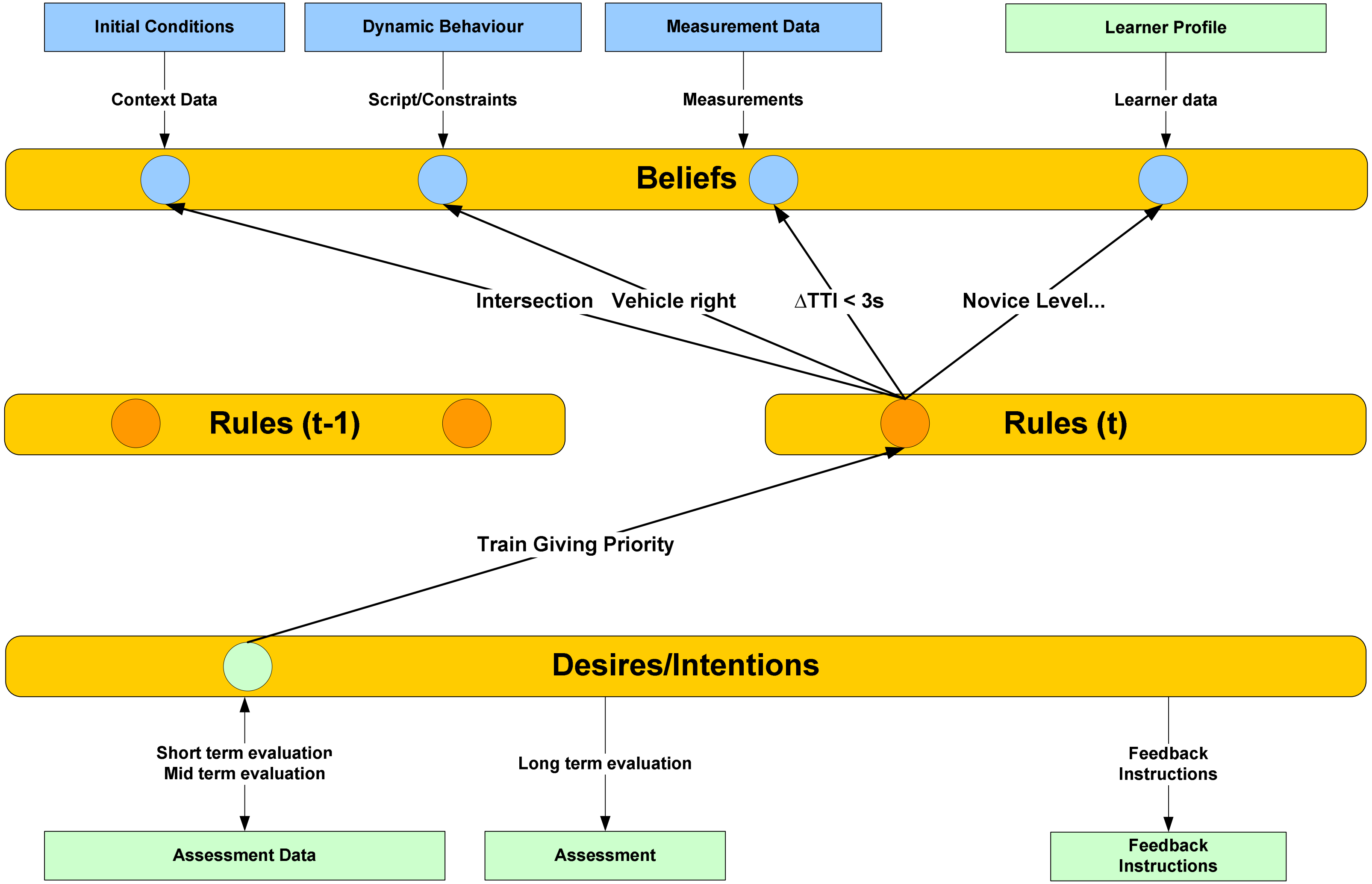
Neural Symbolic Cognitive Agent

Adaptive Training with Cognitive-based Feedback



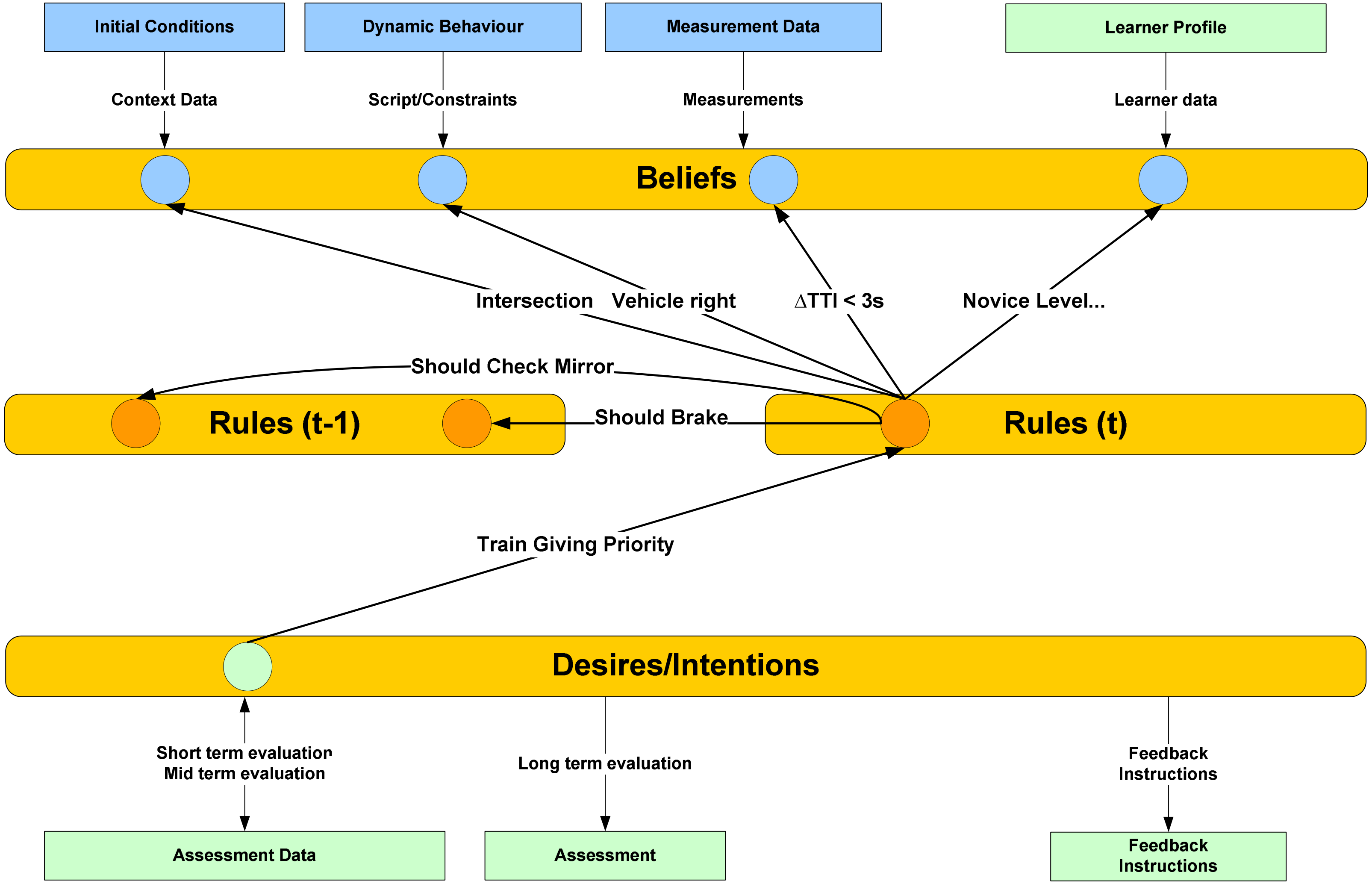
Neural Symbolic Cognitive Agent

Adaptive Training with Cognitive-based Feedback



Neural Symbolic Cognitive Agent

Adaptive Training with Cognitive-based Feedback



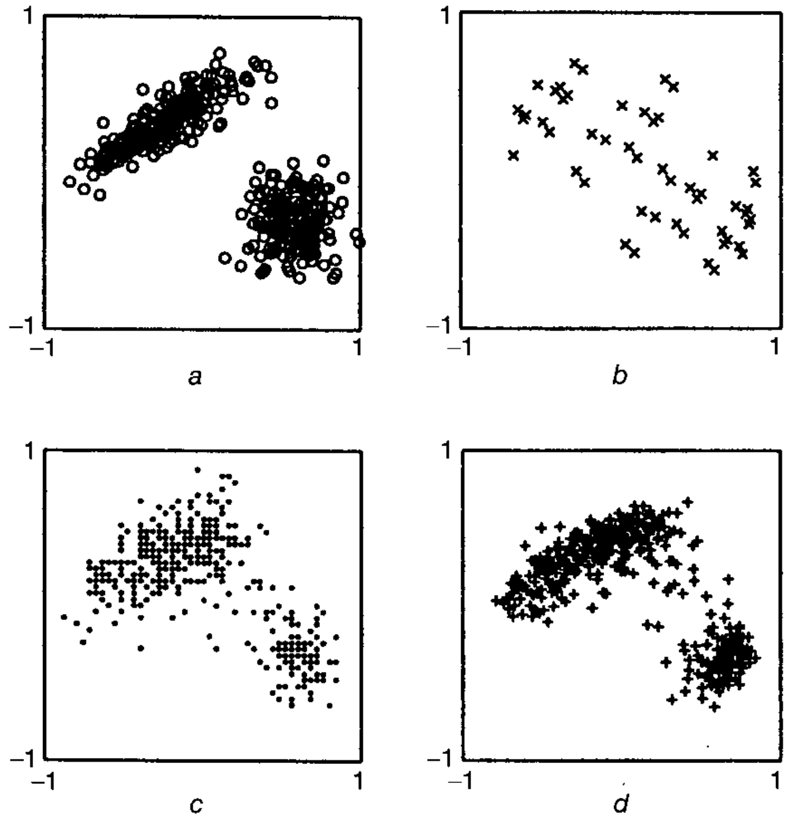
Neural Symbolic Cognitive Agent

Continuous Stochastic Input

$$s_j = \varphi_j\left(\sum_i w_{ij} s_i + \sigma \cdot N_j(0, 1)\right)$$

$$\varphi_j(x_j) = \theta_L + (\theta_H - \theta_L) \cdot \frac{1}{1 + \exp(-a_j x_j)}$$

Trainable noise-control parameter for optimal fit of data distribution



Hsin Chen and Alan F. Murray. *Continuous restricted Boltzmann machine with an implementable training algorithm. In Vision, Image and Signal Processing, IEE Proceedings, pages 153-158, 2003.*

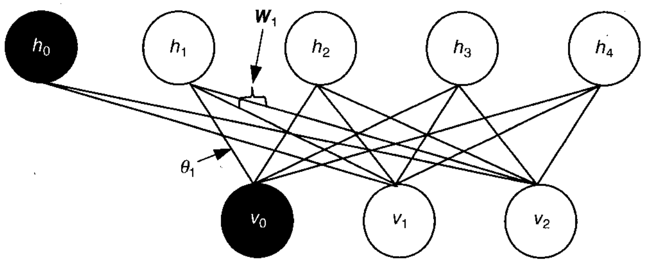
Neural Symbolic Cognitive Agent

Symbolic Extraction and Encoding with Penalty Logic

Penalty Logic Well Formed Formula (PLOFF):

1000	$N \rightarrow R$	Nixon is a Republican
1000	$N \rightarrow Q$	Nixon is also a Quaker
10	$R \rightarrow \neg P$	*R*epublicans tend not to be Pacifist
10	$Q \rightarrow P$	Quakers tend to be Pacifist
3000	N	the person we reason about is Nixon

$$-\frac{1}{2}\sum_{i \neq j} w_{ij} s_i s_j + \sum_j \frac{1}{a_j}\int_0^{s_j} \varphi^{-1}(s)ds$$



***Gadi Pinkas**. Reasoning, nonmonotonicity and learning in connectionist networks that capture propositional knowledge. In Artificial Intelligence v.77 n.2, pages 203-247, September 1995.*

Neural Symbolic Cognitive Agent

Symbolic Extraction and Encoding with a RTRBM

$$\psi = \left\{ \left\langle r_i, R_i \leftrightarrow \bigwedge_{j=1}^{k} \varphi_i^{(j)} \wedge \bigwedge_{l=1}^{m} \rho_i^{(l)} \right\rangle \mid R_i \in R \right\}$$

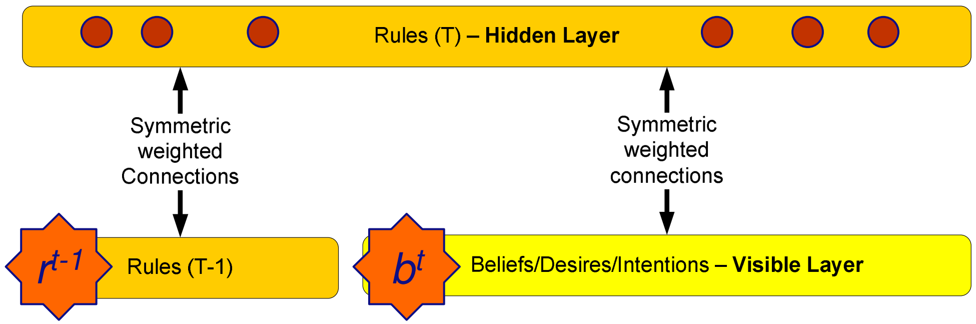
$$r_i \leftarrow P(R_i{=}1 \mid b_i, r^{t-1}{}_i)$$

$$\varphi_i^{(j)} = \begin{cases} B_j \leq b_i(j) & \mid w_{ij} < 0 \\ B_j \geq b_i(j) & \mid w_{ij} > 0 \\ \varnothing & \mid w_{ij} = 0 \end{cases}$$

$$\rho_i^{(l)} = \begin{cases} \bullet\ R_l^{t-1} & \mid r_i^{t-1}(l) = 1 \\ \bullet\ \neg R_l^{t-1} & \mid r_i^{t-1}(l) = 0 \end{cases}$$

$$P(B_j \mid R_i) = P(V^{(j)} \mid H^{(i)}{=}1,\ H^{(x\neq i)}{=}0)$$

$$P(R^{t-1}{}_j \mid R_i) = P(H_{t-1}{}^{(j)} \mid H^{(i)}{=}1,\ H^{(x\neq i)}{=}0)$$



Neural Symbolic Cognitive Agent

From Penalty Logic to Temporal Logic

Conditions:

$(\mathit{Area} = \mathit{urban})$

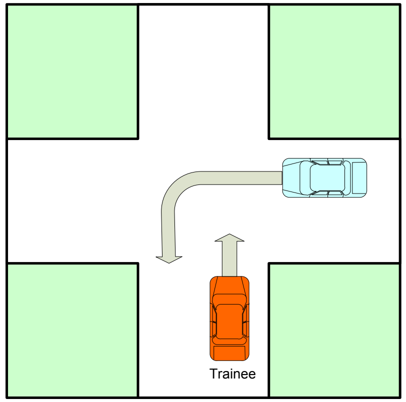
Scenario:

$\mathit{ApproachingIntersection} \wedge \Diamond(\mathit{ApproachingTraffic} = \mathit{right})$

$((\mathit{Speed} > 0) \wedge (\mathit{HeadingIntersection}))\ \mathbb{S}\ (\mathit{DistanceIntersection} < x)$
$\rightarrow \mathit{ApproachingIntersection}$

Assessment:

$\mathit{ApproachingIntersection} \wedge (\mathit{DistanceIntersection} = 0) \wedge$
$(\mathit{ApproachingTraffic} = \text{right}) \wedge \Box(\mathit{Speed} = 0) \rightarrow (\mathit{Evaluation}$ … d)



Fuzzy Evidential Logic:

$\text{B} = \text{true} \leftrightarrow w > 0, \quad \neg\text{B} = \text{true} \leftrightarrow w < 0$
$\Box\text{B} = \text{true} \leftrightarrow w \approx 1, \ \Box\neg\text{B} = \text{true} \leftrightarrow w \approx -1$
$\Diamond\text{B} = \text{true} \leftrightarrow w \approx\ 0, \ \Diamond\neg\text{B} = \text{true} \leftrightarrow w \approx 0$

Temporal Logic:

$$\alpha\mathbb{S}\beta\text{:}\quad \beta \rightarrow \alpha\mathbb{S}\beta$$
$$\alpha \wedge \bullet(\alpha\mathbb{S}\beta) \rightarrow \alpha\mathbb{S}\beta$$

Ron Sun*. A neural network model of causality. In IEEE Transactions on Neural Networks, Vol. 5, No. 4. pages 604-611. July, 1994.*

Luís C. Lamb, Rafael V. Borges, Artur S. d'Avila Garcez*. A Connectionist Cognitive Model for Temporal Synchronisation and Learning. In Proceedings of the Conference on Association for the Advancement of Artificial Intelligence (AAAI), pages 827-832, 2007.*

Results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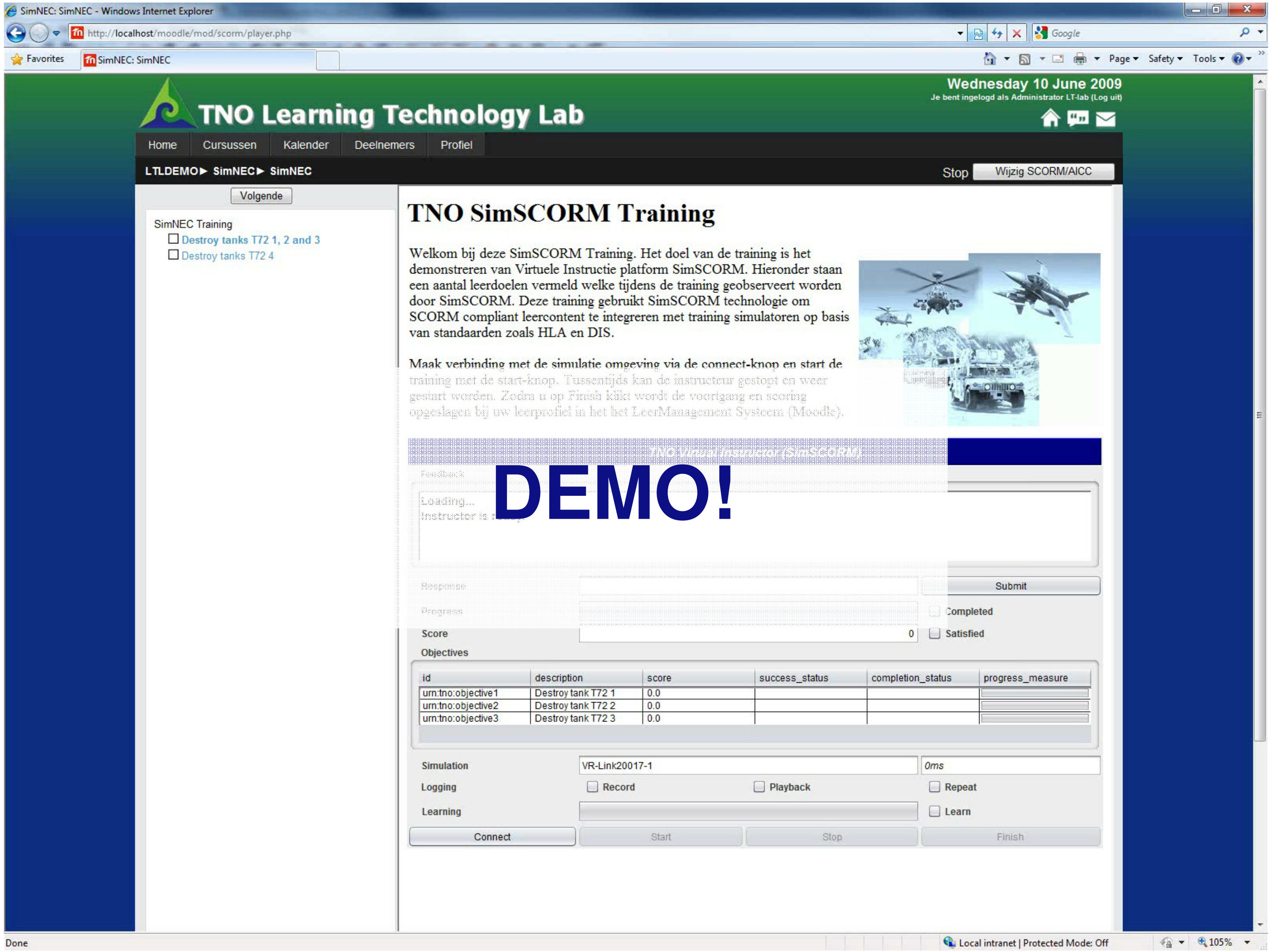
NSCA Prototype

XML PLOFF

Results



TNO Learning Technology Lab
Wednesday 10 June 2009
Home
Cursussen
Kalender
Deelnemers
Profiel
LTLDEMO ▶ SimNEC ▶ SimNEC
Stop
Wijzig SCORM/AICC
Volgende
SimNEC Training
Destroy tanks T72 1, 2 and 3
Destroy tanks T72 4
TNO SimSCORM Training
Welkom bij deze SimSCORM Training. Het doel van de training is het demonstreren van Virtuele Instructie platform SimSCORM. Hieronder staan een aantal leerdoelen vermeld welke tijdens de training geobserveerd worden door SimSCORM. Deze training gebruikt SimSCORM technologie om SCORM compliant leercontent te integreren met training simulatoren op basis van standaarden zoals HLA en DIS.
Maak verbinding met de simulatie omgeving via de connect-knop en start de
DEMO!
Submit
Completed
Score
Satisfied
Objectives
id
description
score
success_status
completion_status
progress_measure
urn:tno:objective1
Destroy tank T72 1
0.0
urn:tno:objective2
Destroy tank T72 2
0.0
urn:tno:objective3
Destroy tank T72 3
0.0
Simulation
VR-Link20017-1
Logging
Record
Playback
Repeat
Learning
Learn
Connect
Start
Stop
Finish

Future Work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- Readable represenation of XML PLOFF in temporal logic and natural language
- Validation of Neural Symbolic Cognitive Agent through validation of extracted rules by Subject Matter Experts (SMEs)
- Unsupervised learning of higher-order rules using Deep Boltzmann Machines


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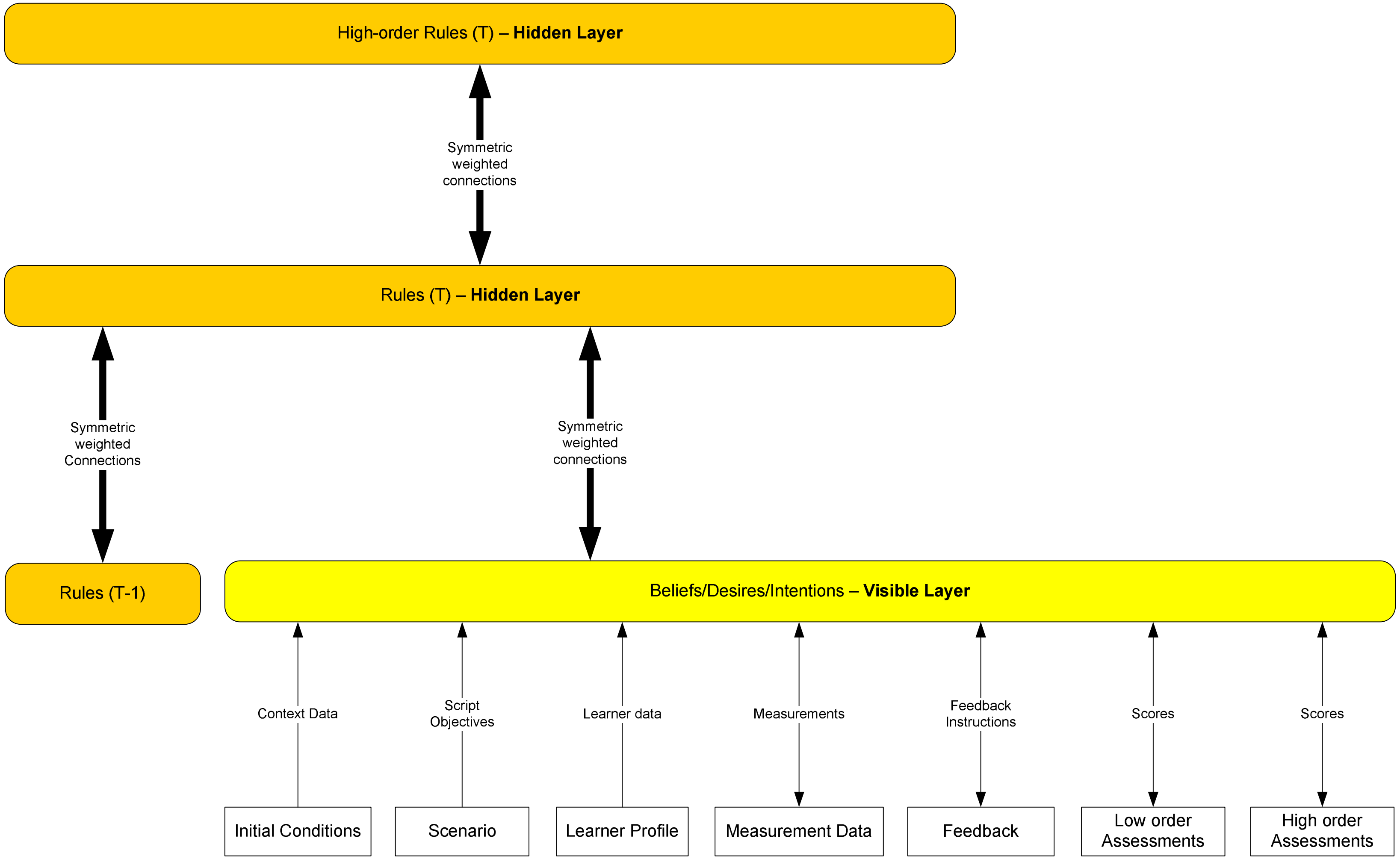
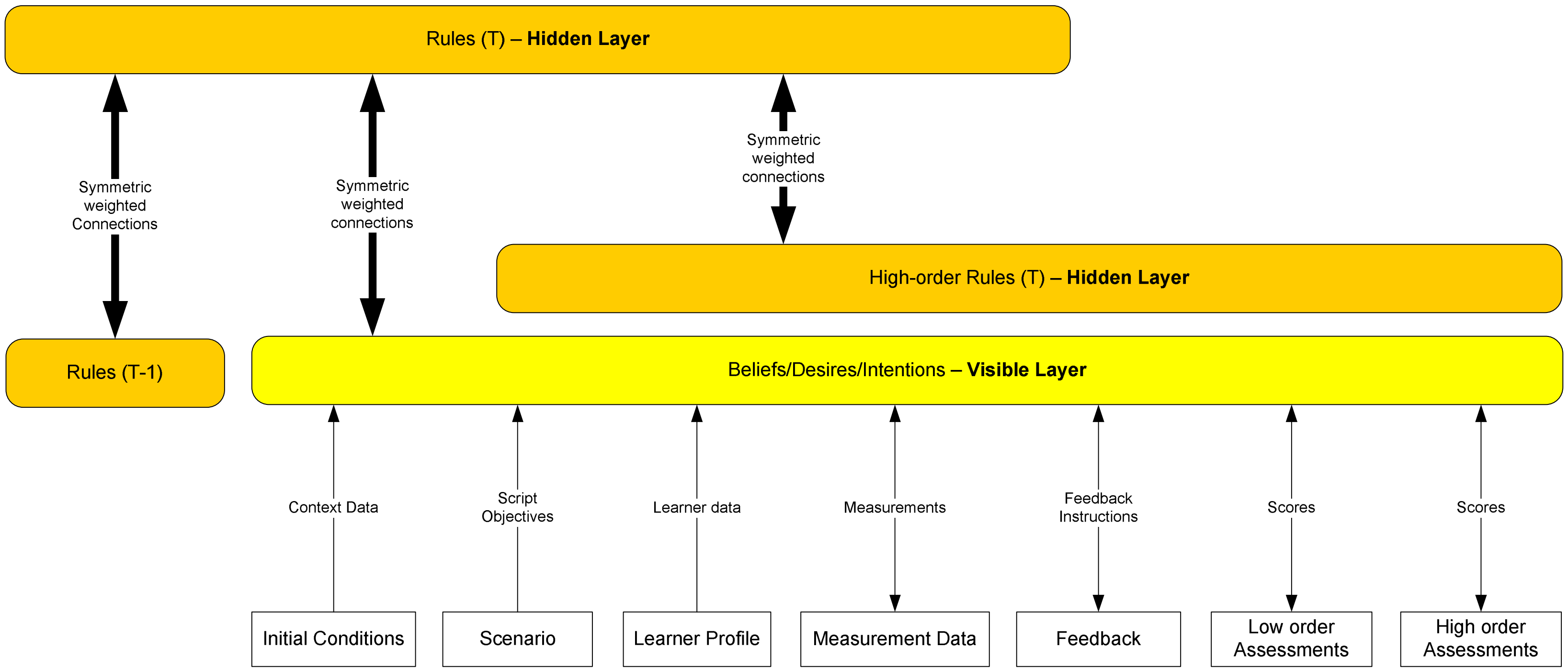
Neural Symbolic Cognitive Agent

Higher-order rules with Deep Boltzmann Machines



Neural Symbolic Cognitive Agent

Higher-order rules with Deep Boltzmann Machines



Conclusions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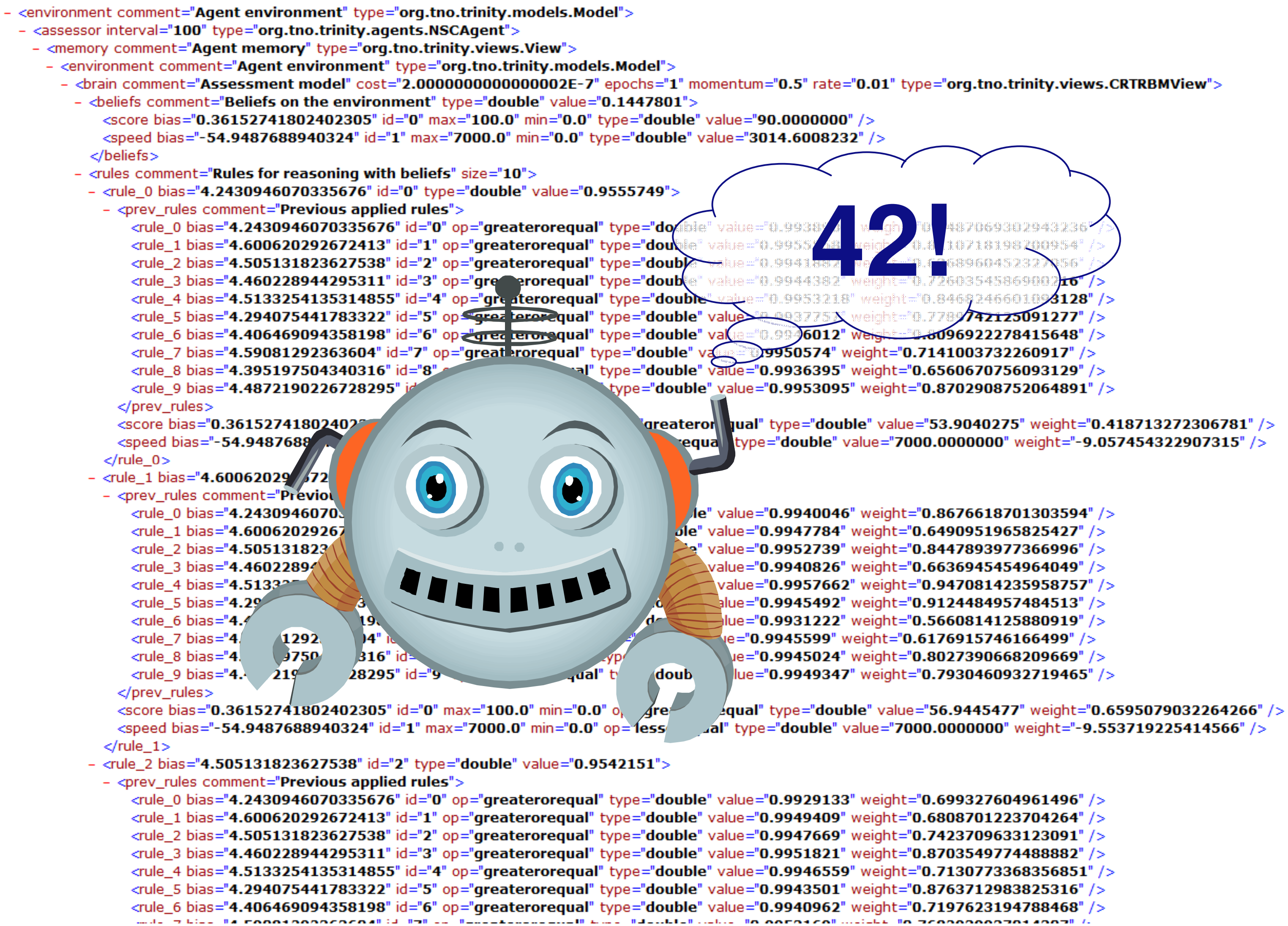
Initial results are promising!

Experiments and validation ongoing

Questions?



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