Towards the integration of abduction and induction in artificial neural networks

Oliver Ray and Artur Garcez

NeSy’06 (August 29th, 2006)

Neural Network Abduction

• Existing Work
  – Diagnostic Problem Solving: inferring diagnoses (faults) from manifestations (symptoms) with Hopfield [GR96] and competition-based [RPT93] neural networks
  – Cost-Based Abduction: specify cost of assuming an abducible with higher-order recurrent networks [AEA05]

• This Work
  – aim: to provide a massively parallel abductive method with no representational restrictions and the ability to handle multiple solutions; and allow the network to be revised by standard connectionist learning methods
  – approach: generalise neuro-symbolic approaches from logic programs to abductive logic programs...

Abductive Logic Programming [KKT92]

• Given
  T Theory – set of normal clauses
  G Goal – set of literals
  IC Integrity Constraints – set of negative clauses
  A Abducibles – set of ground atoms

• Find
  Δ ⊆ A Hypothesis – set of Horn clauses

• Such that
  T ∪ Δ |= ∃G i.e. explanation
  T ∪ Δ ∪ IC |≠ ⊥ i.e. consistent

Example

\[
T = \{ \text{want.start} \leftarrow \text{battery.flat} \\
\phantom{T } \text{battery.flat} \leftarrow \text{wet.day} \\
\phantom{T } \text{wet.day} \leftarrow \text{fan.broke} \\
\phantom{T } \text{lights.on} \}
\]

\[
G = \{ \text{want.start} \}
\]

\[
IC = \{ \bot \leftarrow \text{battery.flat}, \text{lights.on} \}
\]

\[
A = \{ \text{fan.broke}, \text{fuel.empty}, \text{wet.day} \}
\]

\[
\Delta_1 = \{ \text{fuel.empty} \}
\]

\[
\Delta_2 = \{ \text{fuel.empty}, \text{fan.broke} \}
\]

Neuro-Symbolic Translation

\[
H \leftarrow B_1, \ldots, B_n, \neg C_1, \ldots, \neg C_n
\]

\[
\begin{align*}
H & \quad -\left(1/2\right) \\
1 & \quad 1 \\
B_1 & \quad -1 \\
B_n & \quad -1 \\
C_1 & \quad -1 \\
\ldots & \quad -1 \\
C_n & \quad -1 
\end{align*}
\]
We have presented a neural network method for abduction which
– generalises existing translations from logic programs to
abductive logic programs
– provides a neuro-symbolic method for (i) handling non-
acceptable programs, (ii) answering queries, and (iii)
expressing integrity constraints

But variables must be grounded and it remains
to see how this method can be integrated with
neural network learning techniques