Dynamic Data - Driven Brain - Machine Interfaces (DDDBMIs)

José Fortes
On behalf of the DDDBMI PI team:
Renato Figueiredo, Linda Hermer-Vazquez,
José Principe and Justin Sanchez
Brain Machine Interfaces (BMIs)

- **Motor BMIs**
  - Translate brain electrical activity into commands to external devices
  - Command BMIs or BCIs—EEG-based
  - Trajectory control BMIs – based on neuronal firings/fields

- **Signal processing**
  - Many possible models
  - Real-time (20-200 ms)
  - Feedback and training
Kawato’s model

- multiple model pairs
  - forward (planning): sensory input from motor commands
  - inverse (execution): motor commands from trajectory info
- output combines several models
  - data dependent
  - dynamic

Adapted from Wolpert, Kawato, “Multiple paired forward and inverse models for motor control,” Neural Networks 11 (1998)
General considerations

- **Number of model pairs**
  - 10s – 100s for simple tasks (e.g. press lever)
  - 1000s (?) for complex tasks

- **Type of models**
  - Linear (filters): Wiener, NLMS, PVA, …
  - Nonlinear (neural nets): TDNN, RMLP, RNN, NMCLM
  - State-based: Kalman filters, Bayesian classifiers, HMMs

- **Complexity of models**
  - $O(n)$, $O(n^2)$, $O(mn^2)$, $O(n^3)$, …
  - for $n$ neurons, $m$ models
Basic computation structure

- Online – real-time (hard and soft deadlines)
- Offline – recreation of experiments from data in storage
Requirements for Grid-based DDDBMIs

1. resource discovery based on quality of service specifications and scheduling based on virtual machine reservations,

2. dynamic steering of applications to computing resources based on run-time feedback from application inputs.

VAS
Condor-G
GSI/GRAM
VMS
VMShop
1) Resource request; QoS specification
2) Resource selection
3) Virtual cluster reservation, instantiation

RM
PKI/SSH
MPI
VM Plant
VM Plant
VM Plant
VM Plant
VM Plant

140x85
215x132
259x85
402x73
416x127
519x180
468x393
398x619

Advanced Computing and Information Systems laboratory