Emerging Technologies Seminar

Dr. AMIR HEKMATPOUR
IBM Manufacturing Technology Center
Austin, Texas

Biocomputing: Technology, Terminologies, and Trends

The fundamental characteristics of computers have not changed since the birth of electronic machines. In this respect, the evolution of the computers has been very much like that of automobiles and airplanes. Fifth generation computers (still under development) have provided

– **Fifth Generation Computers:**

- – Still under development
- – AI–based computing
- – Silicon–based computers
- – Logical inference mechanisms
- – Limited parallel processing capabilities

– AI has penetrated wide range of application domains
– New expert systems are appearing regularly (Particularly in scientific fields)
– Neurocomputing has emerged as a branch of AI–based computing
– AI languages (PROLOG, LISP) are relatively popular programming language
– Natural language processing is becoming far more sophisticated
– Machine translation systems are now available at PC level

– **Limitation !**

– These developments alone have not – and probably cannot –
cross the threshold into creativity and higher–level cognitive processing

– **Where do we go from here ?**

– The **machines we call computers** have the following characteristics:

- – They are machines designed fundamentally to do calculations
- – They are digital
- – They contain programs
- – They work electronically

– These **fundamental characteristics of computers** have not changed since the birth of electronic machines.

–

– Factors in the progress of computers
  – Emergence of **high level programming** languages
  – Off–the–shelf user friendly/**usable software** and software shells
  – Integrated Circuits Miniaturization (**VLSI**)
  – **Microprocessor** development and standardizations
  – Advancements in **communications** technology

– **Fifth generation computers** (AI–based Computing)
  – An artificial '**Left cerebral hemisphere**' information processing capability
    – Logical, symbolic, and language processing capabilities

– **Sixth generation computers** (Biocomputers)
  – An artificial '**Right cerebral hemispheres**' information processing capability
    – Massive parallel processing
    – Rapid pattern recognition
    – Manipulation of a large volume of analog data

– **Challenge:** Integration of these two modes of information processing (7th generation ??)
    – Corpus Callosum
      – The largest nerve tract in the human brain
      – Connects the two cerebral hemispheres
      – Has had more rapid evolutionary enlargement than even the cerebral cortex
    – Coordinated interaction of the left and right sides of the brain is not a triviality
      – Believe to be an important issue in unraveling of the 'brain code'
    – A significant effort to get 5th and 6th generation computers to 'talk' with one another

– **Biocomputing:**
    – A leap from silicon–based technology to carbon–based organic technology
    – Components which contain organic molecules
    – A large step beyond the most optimistic ideas about 5th generation machines

- **Neurocomputing:**
  - Mimic or simulate in computers the kinds of operations that real brains perform
  - Can be done on the third to sixth generation computers
  - Whether serial (3rd) or parallel (4th), silicon– or carbon–based
  - Deep connections with biocomputing
    - Its design (hardware/software) is based on principles of organization of brain
  - Considered a field within biocomputing

- **Structural gap** between neurocomputers and biocomputers
  - Neurocomputers are silicon computers
    - Architectural or software principles borrowed from the brain
  - Biocomputers have some organic hardware similarities with living nervous systems
    - Architecture ?? Development ?? Integration ??

- **Biocomputing**
  - Biologically–motivated computer architecture
  - Right Brain hemisphere–like capabilities
    - Analog data processing
    - Creativity?
    - Emotion ??
    - Subconscious mind ???
  - Inherently linked to the technology of producing '**Artificial Life**' (AL)

- **Biocomputing Research Requirements/Stages**
  - Deeper understanding of cellular mechanisms
    - Allow the exploitation of the molecules of life
      - Manipulate life forms to a far greater extend
        - Potential for exploring biological forms
          - Possibly altering the biological forms
            - Creating new life forms and/or patterns
              - Artificial Life