

Knowledge Information Processing Software

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1. Objectives

(1) Research in the FGCS Project

Knowledge Representation Technologies

A Parallel Constraint Logic Programming

A Knowledge Representation Language
based on a DOOD theory

Application Systems

Genetic Information Processing

Legal Reasoning

Natural Language Understanding

Games

Expert Systems

(2) Results of the FGCS Project

Knowledge Processing Technologies

GDCC, Quixote

--> Powerful knowledge representation,
Deductive Object-Oriented Database,
Theoretically sound

Application Systems

Genetic Information Processing,

Legal Reasoning

--> Deep analysis of domain knowledge
Effectiveness of parallel inference
Parallel programming techniques

(3) Problems

Knowledge Representation

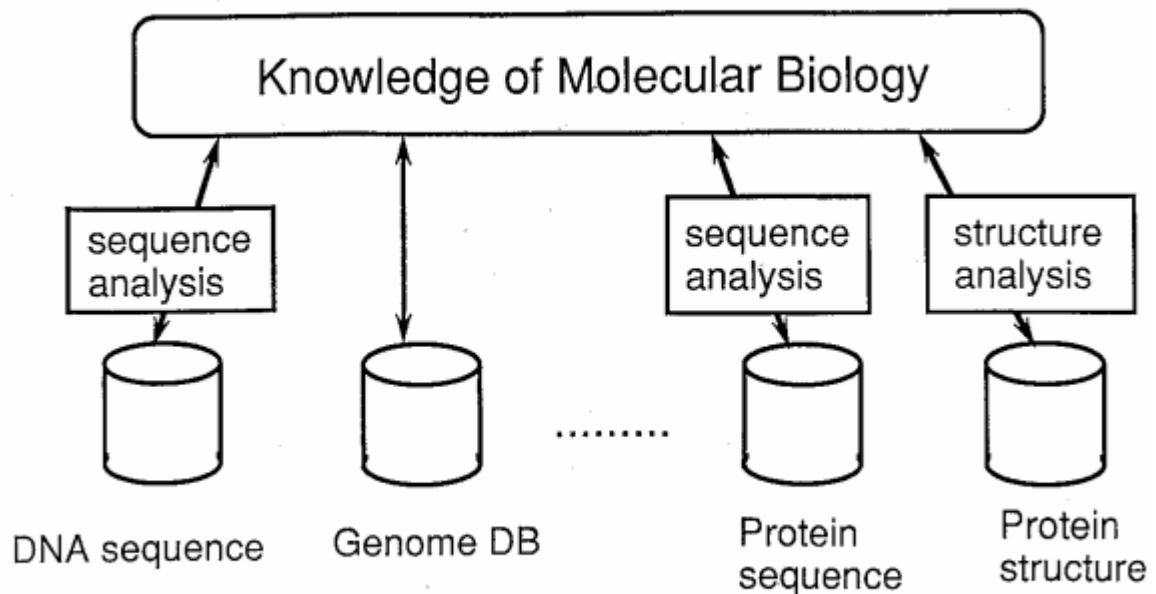
- Large-scaled knowledge processing system
- variety of knowledge
- variety of inference
- unifying problem solvers

Portability

Application Systems

- Extending functions
- Challenging new subjects
- Portability

(4) Example of large scale information processing



(5) Objectives in the FGCS Follow-on Project

- Infrastructure for large scale knowledge processing
- more practical application systems
- portable systems in KLIC
- showing effectiveness of parallel inference

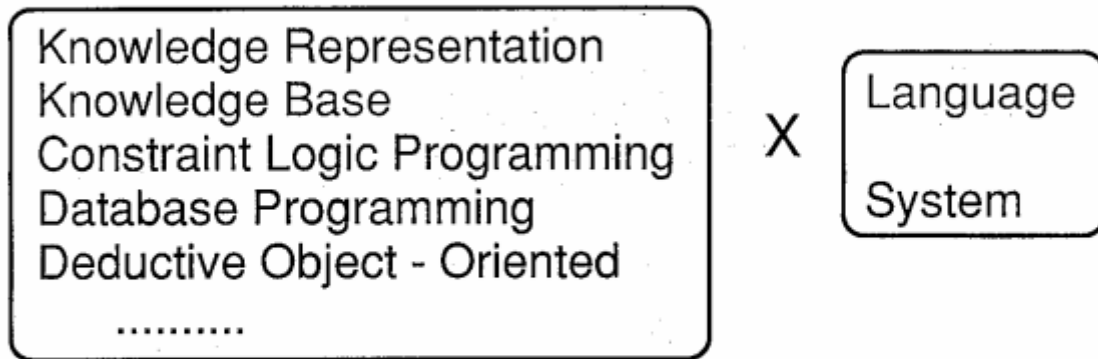
2. Knowledge Representation Technologies

A Knowledge Representation Language
Quixote

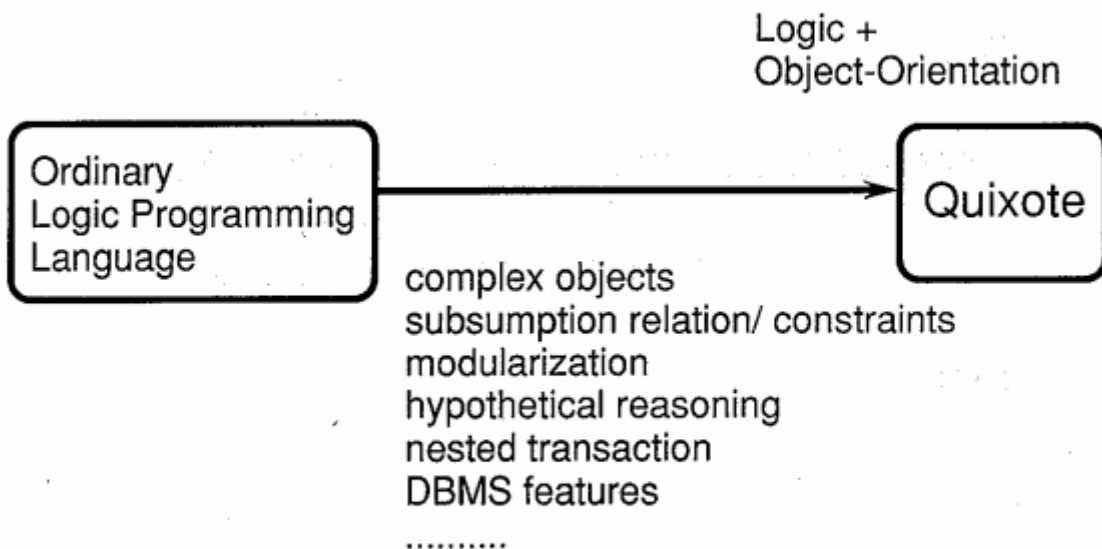
A Heterogeneous Distributed Cooperative
Problem Solving System
HELIOS

2.1 Quixote

(1) What is Quixote



(2) Logic Programming Language and Quixote



(3) Object Term and Subsumption Relation

Object Term

Bobj: apple, color, fruit,
Var: X, Y, Z,

Cobj: apple[color=red],
X@person[employ=X],

Subsumption Relation

apple =< fruit
apple[color=red] =< apple

(4) Rules and Modules

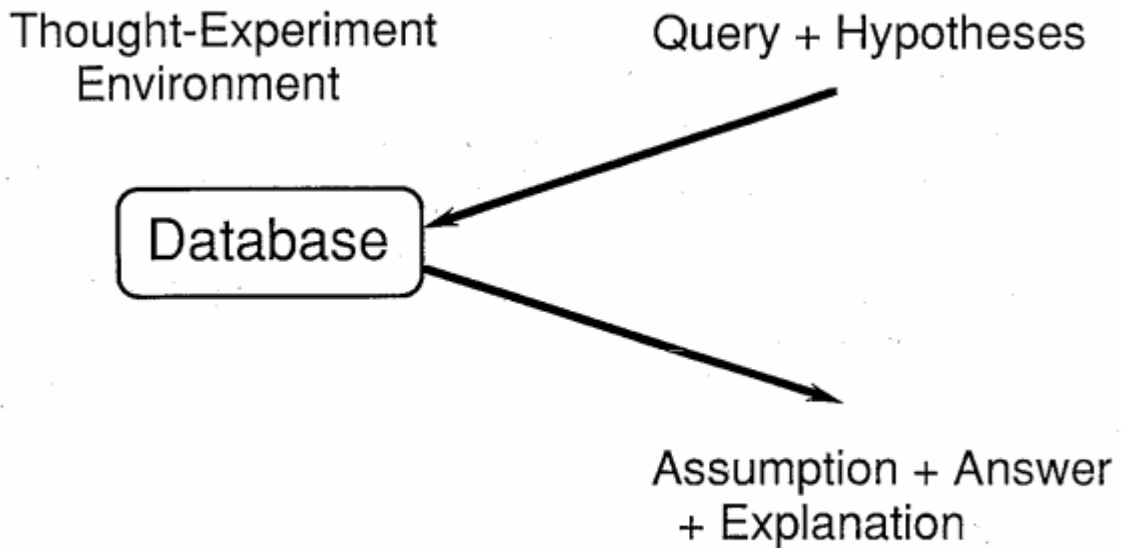
Rule

prosecutor::crime_of_homicide[agt=X]
=< prosecutor:kill[agt=X, obj=Y]
|| {X =< person, Y =< person }.

Module

m1 >- m2

(5) Hypothetical Reasoning



(6) Results in the Follow-on Project

- version 3.0
 - Qmacs, Xwindow
- version 4.0
 - negation as failure
 - KLIC version
- micro Quixote
 - C
- applications
 - Biological KB
 - Legal Reasoning
 - Natural Language Processing

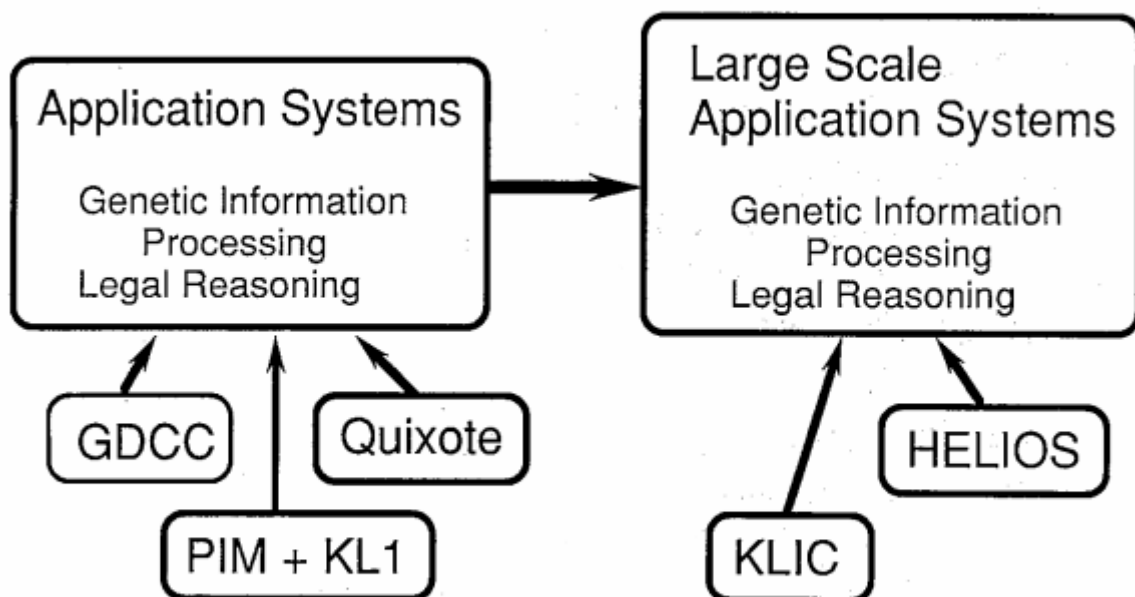
2.2 HELIOS

(1) What is HELIOS

A framework for building large - scaled knowledge processing systems

A heterogeneous distributed cooperative problem solving system

(2) Background



(3) Examples of Heterogeneous Distributed Cooperative Problem Solving

Genetic Information Processing

DBs: DNA sequence, Protein sequence,
Protein structure, motif DB,

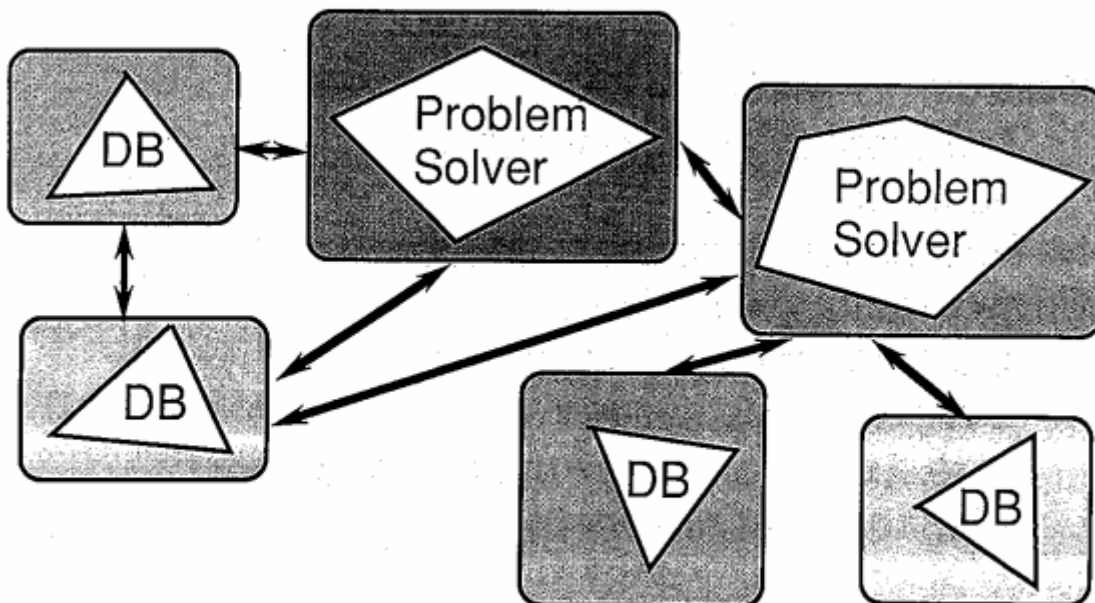
Programs: sequence analysis,
structure prediction, folding simulation, ...

Legal Reasoning

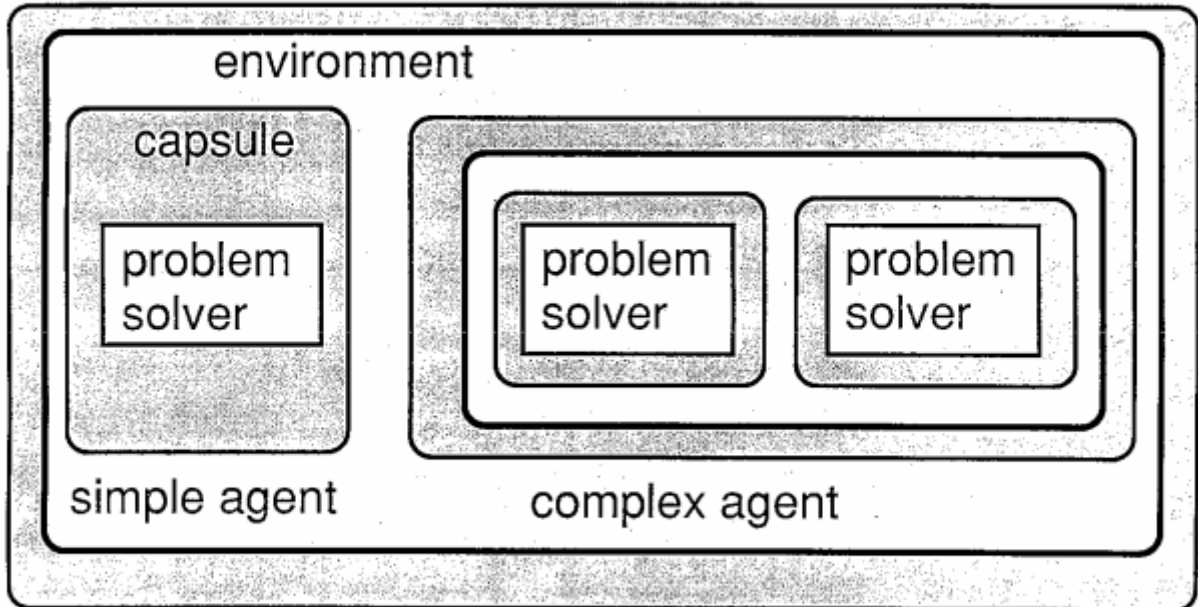
KB/DB: statutes, judicial precedents,
conceptual dictionary,

Programs: Rule base reasoner,
Case base reasoner,.....

(4) Approach



(5) Basic model



(6) Capsule and Environment

Capsule ---> CAPL

Transformation of messages

Definition of methods

Description of solver's function

Environment ---> ENVL

Common message protocol

Common type system

Agent directory and Function directory

Management of execution

(7) Results in the FGCS Follow-on Project

version 1.0

Experiments of communication
between problem solvers

version 2.0

Implementation of CAPL and ENVL

application

Heterogeneous Natural Language Processing

3. Application Systems

Genetic Information Processing

Parallel Applications

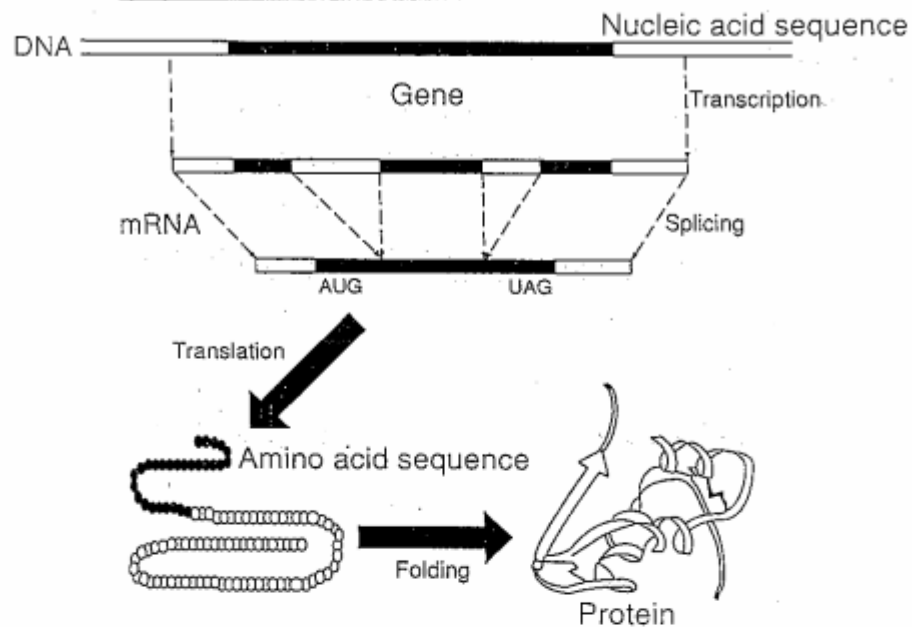
Knowledge Information Processing

Legal Reasoning

new HELIC-II

3.1 Genetic Information Processing

(1) Gene and Protein



(2) What is Genetic Information Processing

- sequence analysis
 - homology search
 - multiple sequence alignment
 - motif extraction
- structure analysis
 - folding simulation
 - prediction of secondary structure
 - prediction of tertiary structure

(3) Multiple Sequence Alignment

Protein sequences

```

HTLV : PVLQLSPAELHSFTHCGQTALTLQGATTTEASNILRSCHACRGGNPQHQMPRGHI
RSV  : QATFQAYPLREAKDLHTALHIGPRALSKACNISMQQAREVVQTCPHCNSAPALEAGVN
MMTV : !SDPIHEATQAHTLHHLNAHTLRLLYKITREQARDIVKACKQCQVATPVPHLGVN
SMRV : ILTAESAQESHALHHQNAALRFQFHITREQAREIVKLCPCPDWGSAPQLGVN
M-MuLV : LHQLTHLSFSKMKALLERSHSPYYMLNRDRTLKNI TETCKACAQVNASKSAVKQGTR
copia : HEKLLHPGIQKTTKLFGETYYFPNSQLLIQNI INECSICNLAKTEHRNTDMPKT
  
```



Sequence Alignment

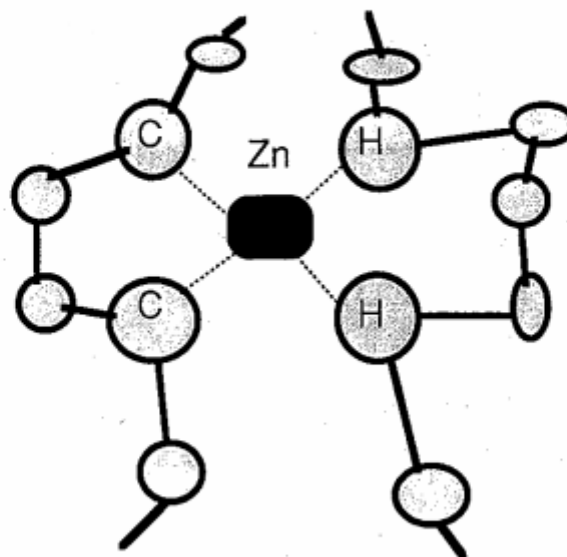
```

HTLV : -PVLQ---LSPA-ELHS-FTHCG---QTAL--TLQ----GATTEA--SNILRSCHAC---RGGNPQHQMPRGHI---
RSV  : QATFQAYPLREAKDLHT-ALHIG---PRAL--SKA---CNISMQQA--REVVQTCPHC-----NSAPALEAG-VN--
MMTV : --ISD--PIHEATQAHT-LHHLN---AHTL--RLL---YKITREQA--RDIVKACKQC---VVATPVPHL--G-VN--
SMRV : --ILT--ALESQESH-A-LHQN---AAAL--RFQ---FHITREQA--REIVKLCPC---PDWGSAPQL--G-VN--
M-MuLV : -----LHQLTHLSFSKMKALLERSHSPYYMLNRDRTL-KNITETCKAC--AQVNASKSAVKQG-TR--
copia : -----HEKLLHPGIQKTTKLF-GET---YYFPNSQLLIQNI INECSICNLAKTEHRNTDM--P-TKTT
  
```

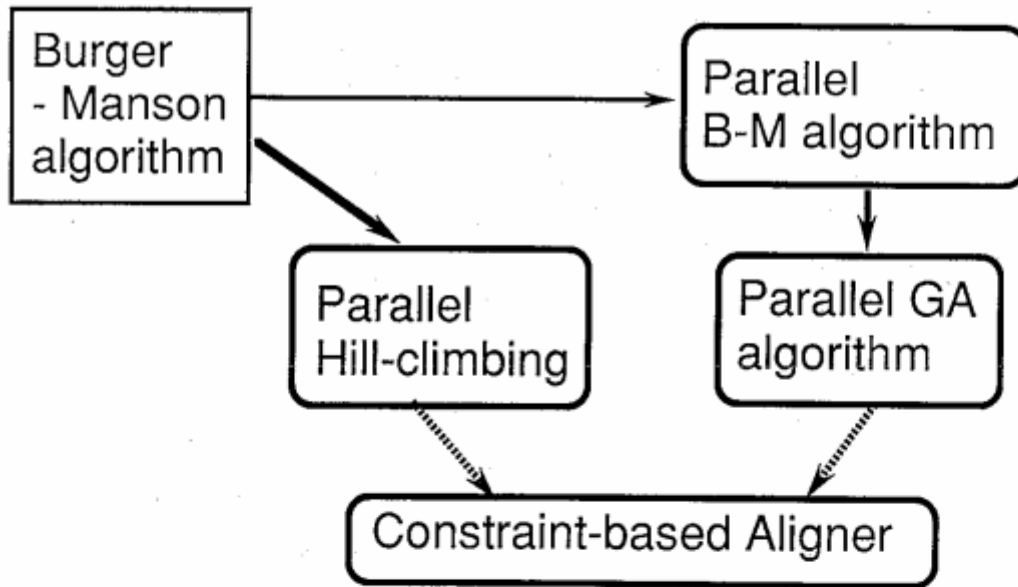
(4) Example of Motif

Zinc Finger

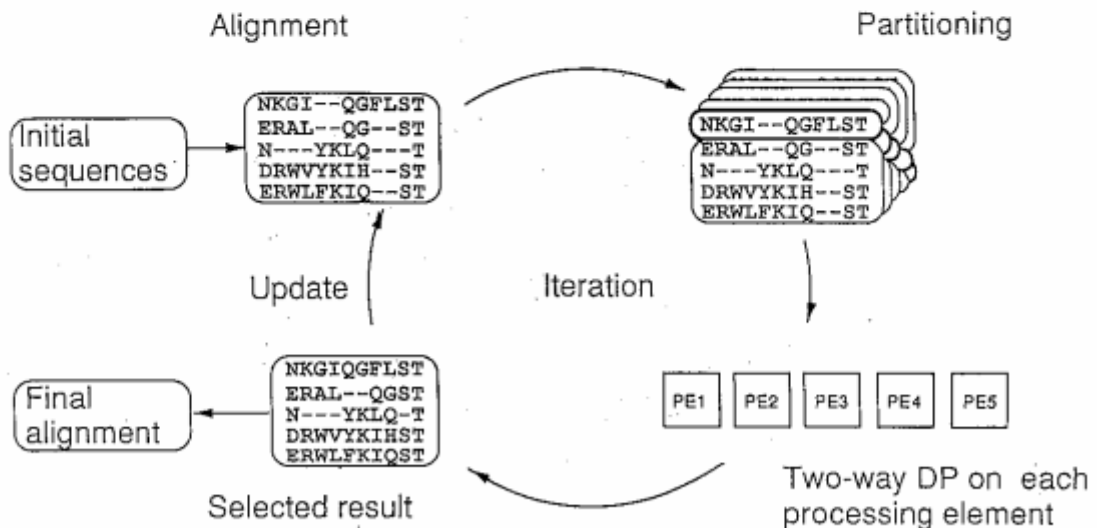
CxxCxxxxxxxxxxxxHxxxH



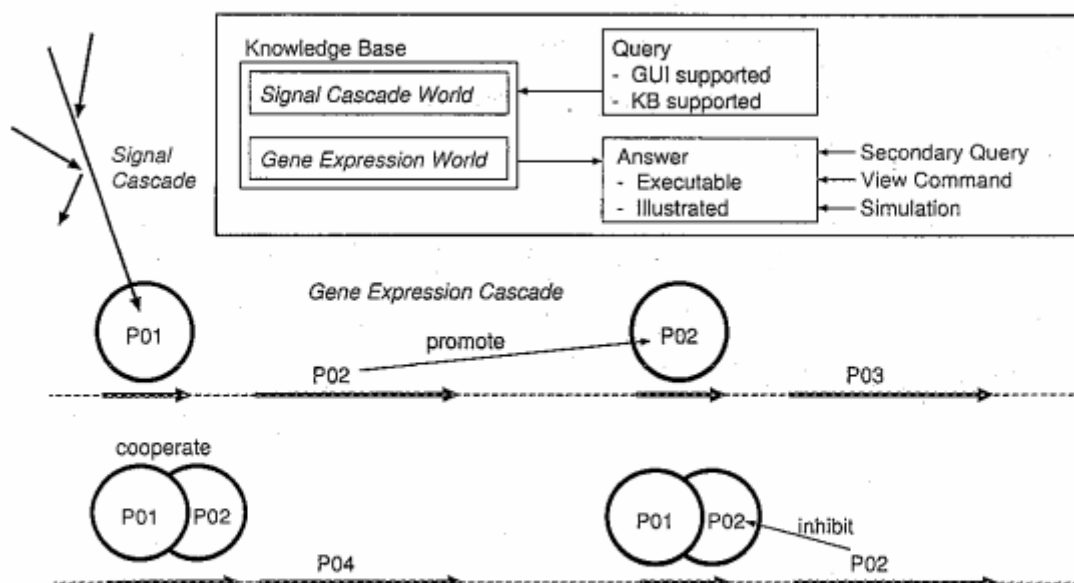
(5) Parallel Multiple Sequence Aligner



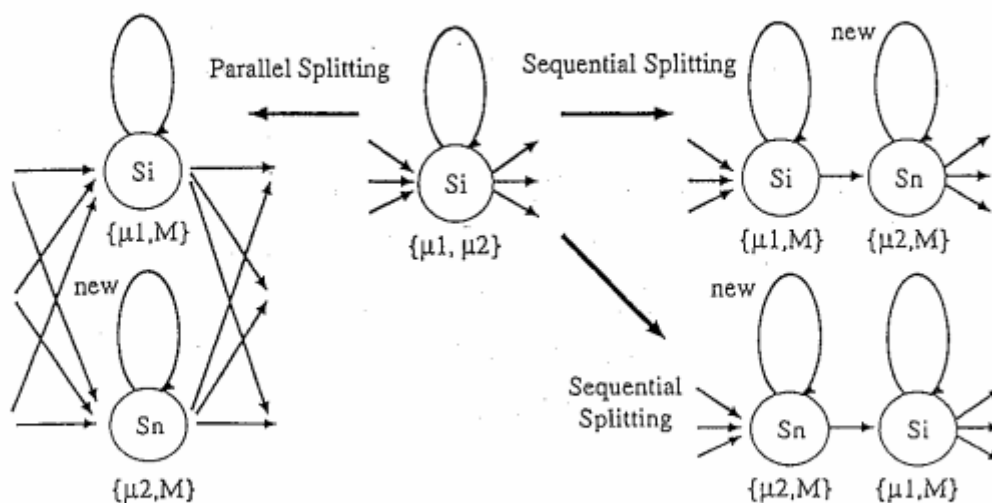
(6) Parallel Multiple Sequence Aligner



(7) Biological KB in Quixote



(8) Stochastic Learning in Hidden Markov Model



(9) Results in the FGCS Follow-on Project

- Multiple sequence aligner
parallel inference, knowledge processing
- Biological KB
Quixote
- Analysis of higher order structure of proteins
Hidden Markov Model
- Analysis of patterns of DNA sequences

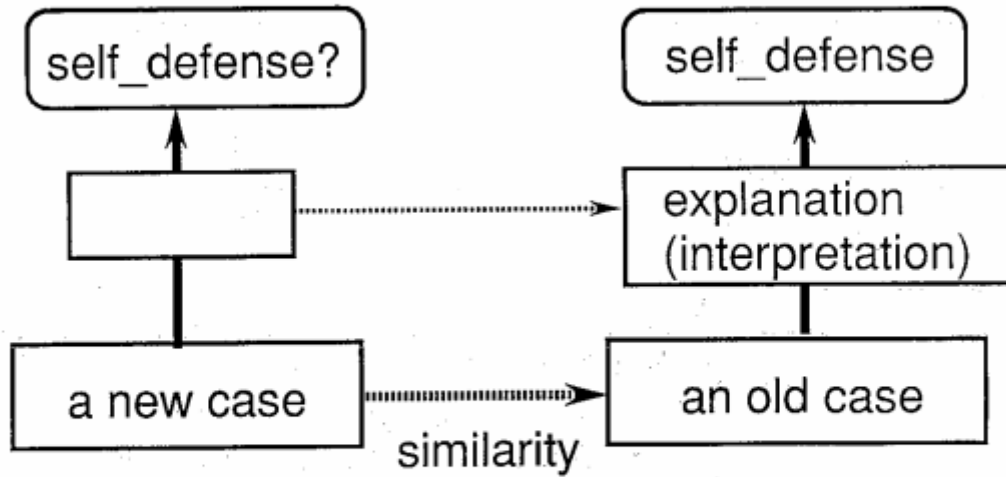
3.2 Legal Reasoning

(1) What is Legal Reasoning

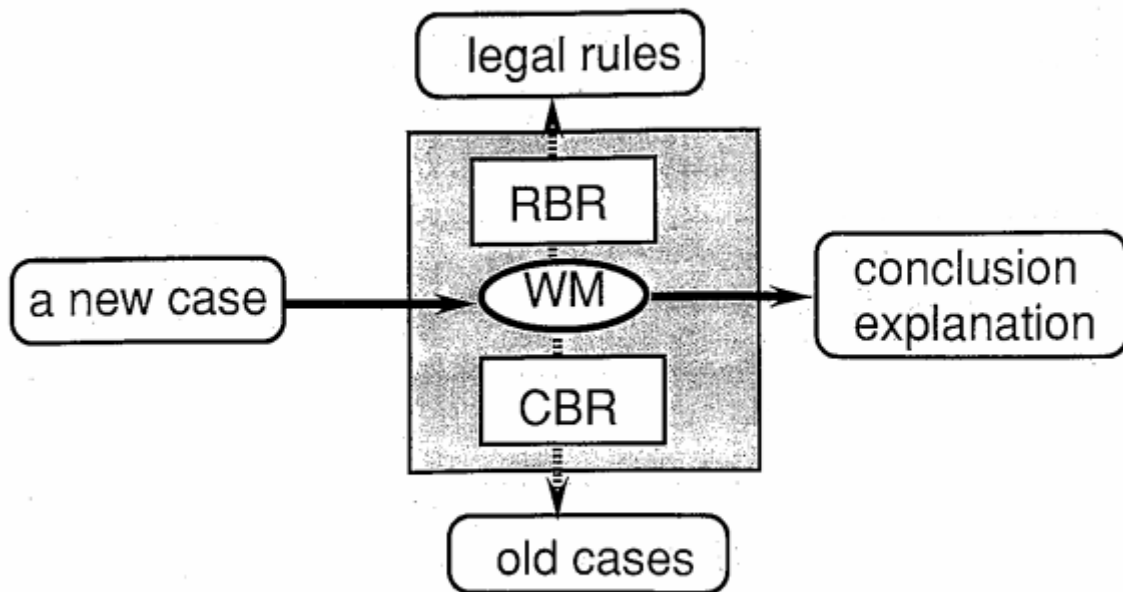
Legal Reasoning = thinking process of lawyers

- generating arguments
Interpretation of rules
application of rules
- selecting arguments
value judgment

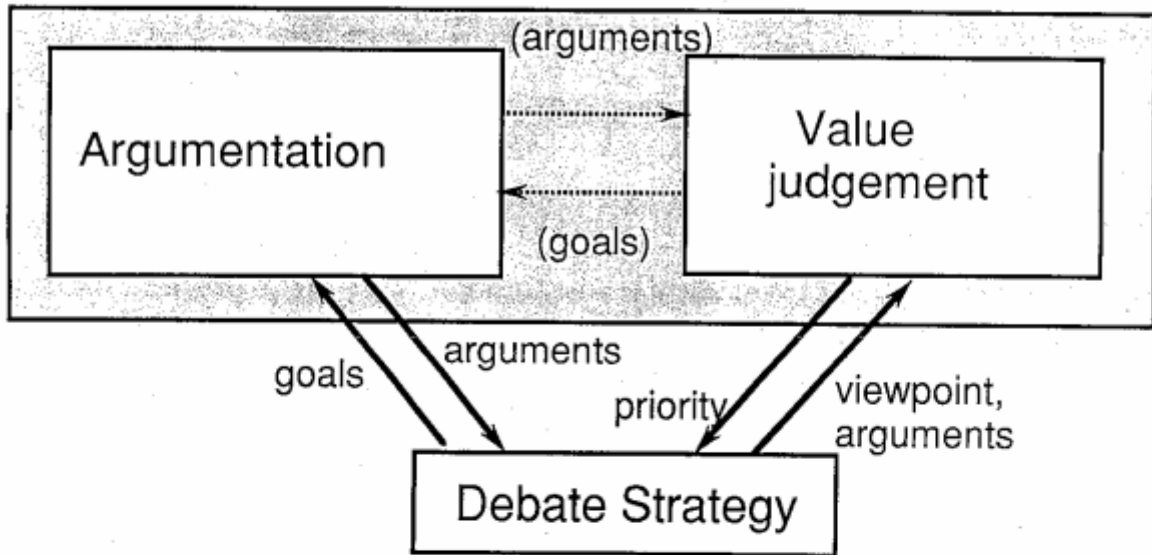
(2) Interpretation and Old Cases



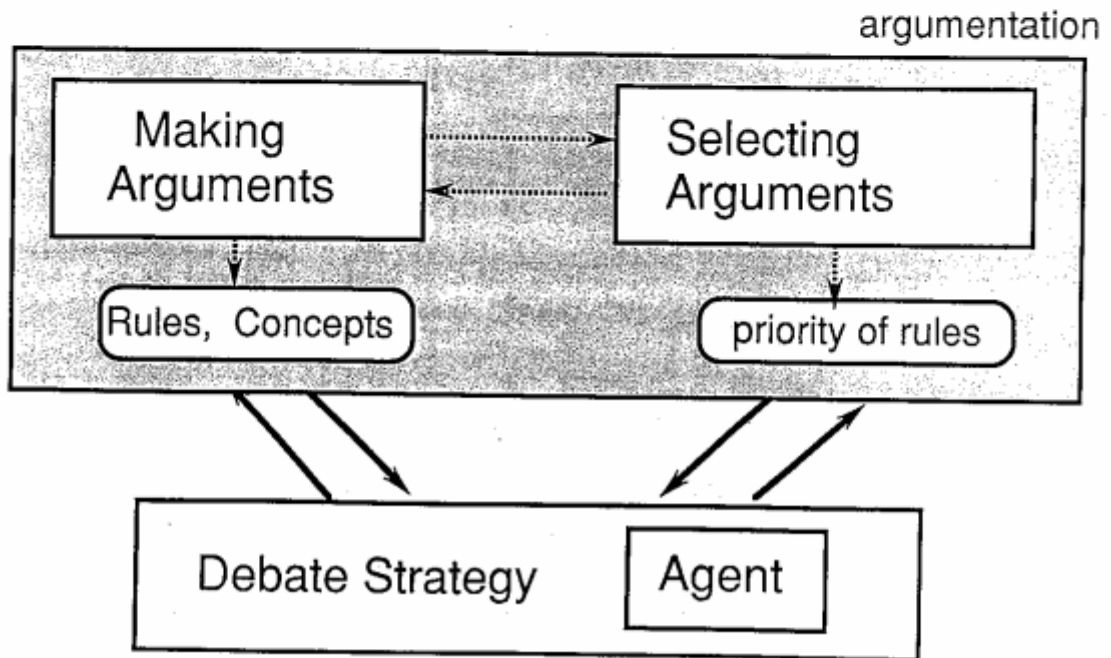
(3) HELIC-II system



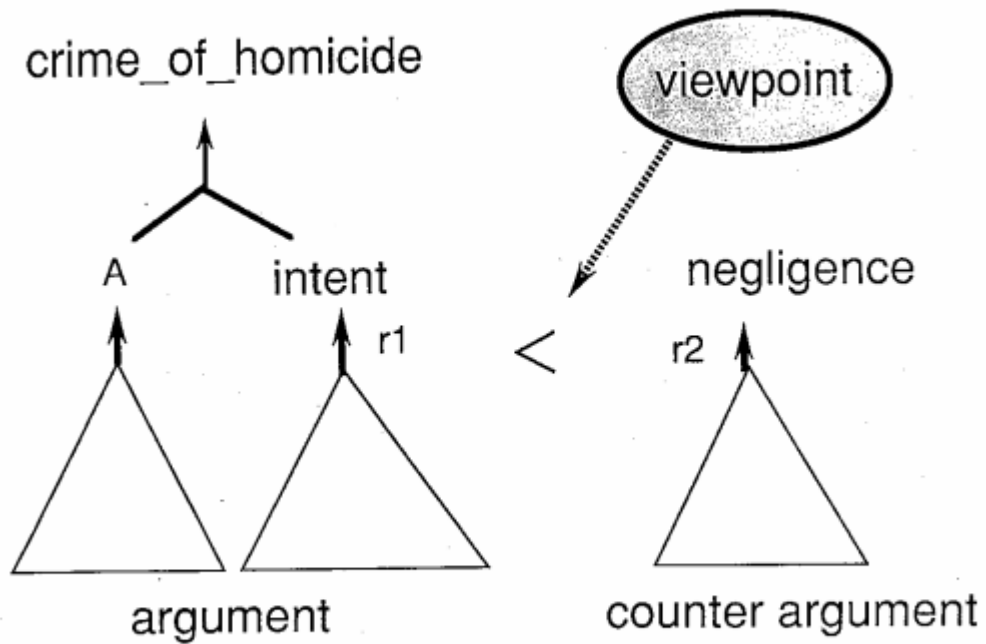
(4) Reasoning of Lawyers



(5) Legal Reasoning Model



(6) Defeasible Reasoning



(7) Debate Strategy

Debate by two agents

- making (counter) arguments
- comparing arguments
- finding issues
- modifying a viewpoint

(8) Result in the FGCS Follow-on Project

new HELIC-II system

a legal reasoning model

argumentation + value judgment
+ debate

an experimental tool for legal reasoning

KB of criminal law

4. Towards large-scaled knowledge processing

(1) From viewpoint of KR

Genetic Information Processing
Legal Reasoning

good examples of multi-agent system.

incomplete domain knowledge
various types of knowledge
public databases

(2) From viewpoint of Genetic Information Processing

Quixote --> a powerful KR language
a biological KB
metabolic reaction
a motif DB
constraint-based
multiple sequence alignment
HELIOS --> a paradigm for unifying problem solvers
and databases
total systems

(3) From viewpoint of Legal Reasoning

Quixote --> a powerful KR language
legal rules, precedents, theories,...
+ α --> higher order inference mechanism
selecting arguments
HELIOS --> a paradigm for unifying problem solvers
and databases
a total system

5. Conclusion

Knowledge processing technologies

- Knowledge Representation

 - Quixote: new functions + KLIC

 - HELIOS: a new paradigm for

 - large - scaled KB systems

- Application Systems

 - GIP: analysis tools + KB approach

 - + Hidden Markov Model

 - Legal Reasoning:

 - legal reasoning model + KR language