



THE SP SYSTEM AND ITS POTENTIAL APPLICATIONS IN DEFENCE

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THE SP SYSTEM

Very roughly, the **SP theory of intelligence** (expressed in the **SP computer model**) is:

- A **database system**...
- ...with **intelligence**.

SIMPLIFICATION AND INTEGRATION

- Computer science, including artificial intelligence, has become very **fragmented**.
- The SP system aims to **simplify** and **integrate** observations and concepts in AI and related areas .
- The key to simplification and integration is the **multiple alignment** concept (next).



MULTIPLE ALIGNMENT: A CONCEPT BORROWED (AND ADAPTED) FROM BIOINFORMATICS

```

G G A      G      C A G G G A G G A      T G      G      G G A
| | |      |      | | | | | | | | |      | |      | | | |
G G | G    G C C C A G G G A G G A      | G G C G      G G A
| | |      | | | | | | | | | | |      | |      | | | |
A | G A C T G C C C A G G G | G G | G C T G      G A | G A
| | |      | | | | | | | | | | |      | |      | | | |
G G A A      | A G G G A G G A      | A G      G      G G A
| | |      | | | | | | | | |      | |      | | | |
G G C A      C A G G G A G G      C      G      G      G G A
```

- “Stretching” of sequences in a computer brings matching letters into line.
- Heuristic methods are needed because the search is complicated.

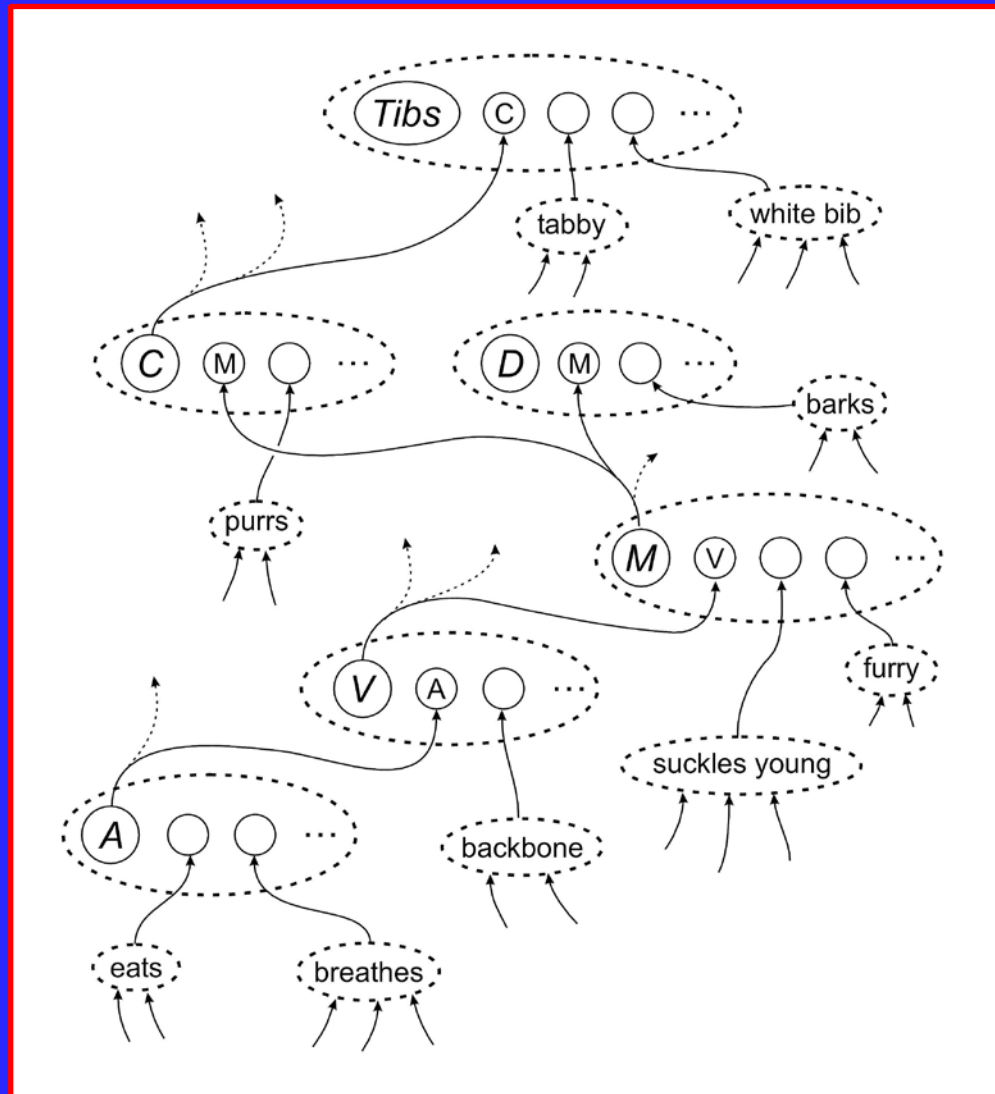
AN SP MULTIPLE ALIGNMENT

0			t	h	e			a	p	p	e	s		a	r	e		s	w	e	e	t	0
1								N	Nr	6	a	p	p	e	#N								1
2							N	Np	N	Nr			#N	s	#N								2
3			D	17	t	h	e	#D															3
4			NP	0a	D		#D	N					#N	#NP									4
5														V	Vp	11	a	r	e	#V			5
6	S	Num	;	NP									#NP	V				#V	A				6
7																		A	21	s	w	e	7
8	Num	PL	;				Np						Vp										8

- **SP-multiple alignment** is central in the SP system.
- The **versatility** of **SP-multiple alignment** (described later) is a major discovery.
- **SP-multiple alignment** could be the “double helix” of intelligence.

SP-NEURAL

Concepts in the SP system may be mapped into **SP-neural**, meaning the SP theory expressed as neurons and their inter-connections.



COMPARISON WITH OTHER AI-RELATED SYSTEMS

- A recent paper describes several **advantages** of the SP system compared with several AI-related alternatives.
- There are at least 14 problems with deep learning which are solved in the SP system.

VERSATILITY AND ADAPTABILITY OF THE SP SYSTEM

- **Unsupervised learning**: a foundation for all other kinds of learning.
- Representation of **several different kinds of knowledge**.
- **Several different kinds of reasoning**.
- **Pattern recognition and computer vision**:
 - Robust in the face of errors in data;
 - At multiple levels of abstraction.
- Processing of **natural language**.
- **Information storage and retrieval**.
- **Planning a route between two places**.
- **Solving the kinds of problem used in IQ tests**.

SEAMLESS INTEGRATION IN THE SP SYSTEM

- SP-multiple alignment has potential to be a **universal framework** for diverse kinds of knowledge (DK) and diverse aspects of intelligence (DI).
- This gives the SP system potential for the **seamless integration** of DK and DI — (SIDKDI).
- SIDKDI appears to be **essential** if we are to achieve human-like fluidity, versatility and adaptability in artificial intelligence. For example, **in solving “whodunnit” problems, detectives naturally make use of many different kinds of knowledge and many different aspects of intelligence.**

A HIGH-PARALLEL SP MACHINE AS A STEP TOWARDS AN INDUSTRIAL-STRENGTH SYSTEM, AND AS A VEHICLE FOR RESEARCH

SP theory and SP computer model



High parallel
In the cloud

SP MACHINE

Open source
Good user interface

Representation of knowledge

Natural language processing

Several kinds of reasoning

Planning & problem solving

Information compression

Unsupervised learning

Pattern recognition

Information retrieval

MANY APPLICATIONS

THE POTENTIAL OF THE SP SYSTEM IN DEFENCE — SUMMARY

- The SP system as a **versatile database system**, with **intelligence**.
- Helping to solve **nine problems with big data**.
- Helping to develop human-like intelligence in **autonomous robots**.
- **Unsupervised learning**.
- Several kinds of **reasoning**.
- **Planning and problem solving**.
- **Pattern recognition and computer vision**.
- Processing of **natural languages**.
- The detection and management of **errors in data**.
- **Data fusion**.
- **Transparency and visualisation**.

THE SP SYSTEM AS A VERSATILE DATABASE SYSTEM, WITH INTELLIGENCE

- **Storage** of information
 - Efficiency in the use of storage space.
 - Efficiency in the transmission of information.
- **Retrieval** of information
 - Query-by-example.
 - Natural language queries.
 - SQL.
- **Versatility** in representing different kinds of knowledge and with different aspects of intelligence.
- **Seamless integration** of different kinds of **knowledge** and different aspects of **intelligence**.

BIG DATA

The SP system can help solve **nine problems with big data**:

- Overcoming **the problem of variety** in big data.
- The **unsupervised learning** or discovery of ‘natural’ structures in data.
- **Interpretation of data**: pattern recognition etc.
- **Velocity**: analysis of streaming data.
- **Volume**: making big data smaller.
- **Model-based coding**: additional economies in the transmission of data.
- **Energy**, speed, and bulk.
- **Veracity**: managing errors and uncertainties in data.
- **Visualisation**: knowledge structures and processing.

HELPING TO DEVELOP HUMAN-LIKE INTELLIGENCE IN AUTONOMOUS ROBOTS

- Human-like versatility in skills may be developed via **unsupervised learning** in the SP system.
- This contrasts with bespoke software for each skill.
- Parallel processes may be managed via two-dimensional patterns in the SP system.

UNSUPERVISED LEARNING

- The SP system has strengths and potential in **unsupervised learning** (the inspiration for the system).
- It means learning **without a “teacher”** or anything equivalent. Most human learning is unsupervised.
- It is the foundation for “reinforcement learning”, “learning by imitation”, “learning by being told”, and more.
- For defence, it can mean:
 - The discovery of significant **structures, patterns, or associations** in data.
 - Automatic or semi-automatic **organisation of unstructured or semi-structured** information.

SEVERAL KINDS OF REASONING, WITH OTHER ASPECTS OF INTELLIGENCE

- The SP system supports **several kinds of reasoning** that can work together and with **other aspects of intelligence (such as planning and problem solving)**, in any combination. **This is a major strength of the system.**
- For defence, this can mean:
 - Helping to anticipate and head off acts of terrorism.
 - Helping to work out the possible implications of knowledge about an enemy.
 - Helping to develop military strategies and tactics.

PATTERN RECOGNITION AND COMPUTER VISION

The SP system has strengths and potential in:

- Recognising patterns in data, including such things as patterns of activity, or language styles, that have been previously learned by the system.
- Recognising or retrieving such things as finger prints or DNA samples that are **the same as** or **similar to** a given target.
- Computer vision: analysis and interpretation of scenes, recognition of people from different angles, recognition of objects and their significance,

PROCESSING OF NATURAL LANGUAGE

- The SP system has strengths and potential in:
 - Parsing (analysis) and production of natural language without meanings.
 - Understanding natural language and production of language from meanings.
 - Translation between natural languages via meanings.
- Potential applications in defence, include understanding conversations by suspects, understanding legal documents, and help in composing reports.
- Seamless integration of NL with other aspects of intelligence.
- More ambitious than NL in current AI applications.

THE DETECTION AND MANAGEMENT OF ERRORS IN DATA

- Pattern recognition and learning are robust in the face of errors in data.
- This allows the system to detect errors in data, including errors from deception.

DATA FUSION

- Streams of information from two or more sensors often need to be combined into a coherent whole.
- This can be done if each stream contains information, such as the time of each reading, which can be matched with corresponding information in other streams.
- That kind of matching and merging of information is what the SP system does.

TRANSPARENCY AND VISUALIZATION

- In the SP system there is **transparency** in:
 - **How knowledge is organised** (cf deep learning and artificial neural networks).
 - **Processing** — there is an **audit trail** for all processing.
- Static and moving **graphics** may help **visualisation** of knowledge and processing.
- This is likely to be important in:
 - Assessments of **security** against crime or terrorism.
 - **Legal issues** arising from crime or terrorism.



FURTHER INFORMATION

- www.cognitionresearch.org/sp.htm .
- **Papers:** There are details of several papers, many with download links, on the above web page.
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