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PRESS RELEASE

Biochemistry provides inspiration for a new kind of AI

The **SP System** (SPS), meaning the **SP Theory of Intelligence** and its realisation in the **SP Computer Model**, is <mark>a radically new kind of AI with several advantages compared with the currently popular deep neural networks (DNNs)</mark>—notwithstanding some impressive achievements with DNNs.

The reference to biochemistry in the title of this press release is how "<mark>*multiple sequence alignment,*</mark>" an analytic technique used by biochemists, was an important inspiration for the SPS. It means arranging (symbolic representations of) two or more DNA sequences (or sequences of amino acid residues) so that symbols that match each other from one sequence to another are brought into alignment, like this:

```
              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
```

The inspiration was that, with some adaptation, something like multiple sequence alignment might be a means of modelling several aspects of intelligence.
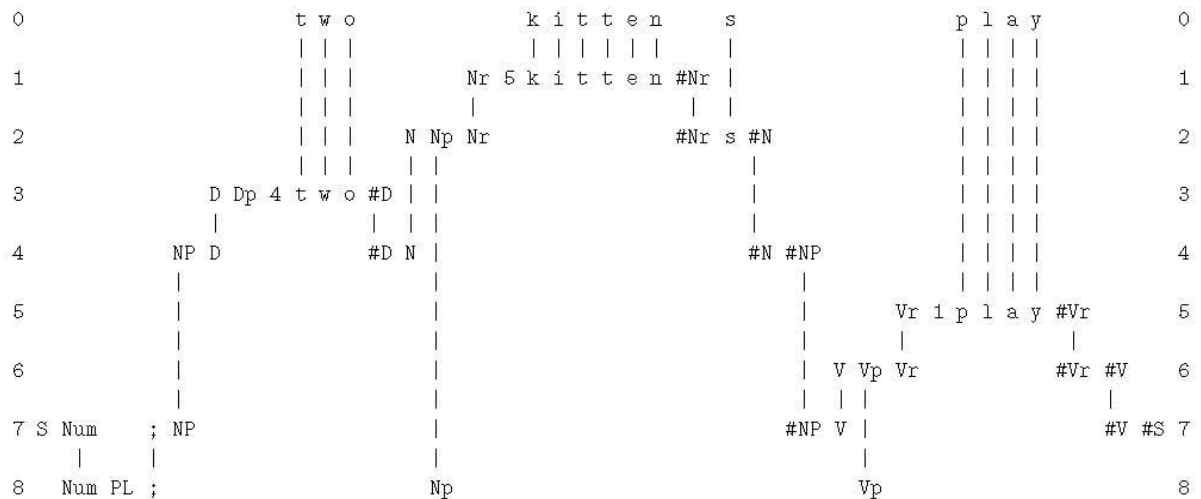
That idea only took a few hours to take shape, but a much longer period—about 17 years—has been needed to develop the new concept of **SP-multiple-alignment**, to make it work within the SP Computer Model, to explore its range of intelligence-related applications, and to write a book about the research:

"*Unifying Computing and Cognition*" (tinyurl.com/yyybwsuc).

A shortened version of the book is "The SP Theory of Intelligence: an overview" (PDF, *Information*, 4 (3), 283-341, 2013, bit.ly/1NOMJ6l). A description of the origins, development, and advantages of the SP System, is in an article with the same title as this press release: *Biochemistry provides inspiration for a new kind of AI* (PDF, tinyurl.com/3vh3hxwe).

Much of the work was developing and testing **hundreds** of versions of the SP-multiple-alignment software, to find what worked best.

Here is an example of an SP-multiple-alignment from the SP Computer Model as it is now:

```
0          t w o           k i t t e n       s           p l a y       0
           | | |           | | | | |         |           | | | |
1          | | |       Nr 5 k i t t e n #Nr  |           | | | |       1
           | | |           |               |  |          | | | |
2          | | |     N Np Nr              #Nr  s #N       | | | |       2
           | | |       | |                    |           | | | |
3      D Dp 4 t w o #D | |                     |           | | | |       3
       |           | | |                       |          | | | |
4    NP D        #D N |                    #N #NP          | | | |       4
     |             |                          |           | | | |
5    |             |                          |       Vr 1 p l a y #Vr  5
     |             |                          |          |       |
6    |             |                          | V Vp Vr          #Vr #V  6
     |             |                          | | |                |
7 S Num    ; NP    |                       #NP V |              #V #S 7
     |     |       |                          |
8    Num PL ;      Np                        Vp                       8
```

Although this is an alignment of sequences, the overall effect is to analyse or parse the sentence in row 0 into its parts and sub-parts. But ==many other things can be done with the SP-multiple-alignment concept, not just the parsing of sentences.==

In brief, the strengths and potential of the SP Computer Model, with the SP-multiple-alignment concept at centre-stage, are:

1. ==*The clear potential to solve 19 problems in AI research*,== 17 of them identified by influential experts in AI in interviews with science writer Martin Ford, and reported by him in his book *Architects of Intelligence* (tinyurl.com/tytjjb4). Most of those problems are problems with DNNs.

2. ==*Strengths and potential in aspects of intelligence*== including: unsupervised learning; the analysis and production of natural language; pattern recognition that is robust in the face of errors in data; pattern recognition at multiple levels of abstraction; computer vision; best-match and semantic kinds of information retrieval; several kinds of reasoning (next bullet point); planning; and problem solving.

3. ==*Versatility in kinds of reasoning*,== including one-step 'deductive' reasoning; chains of reasoning; abductive reasoning; reasoning with probabilistic networks and trees; reasoning with 'rules'; nonmonotonic reasoning and reasoning with default values; Bayesian reasoning with 'explaining away'; causal reasoning; reasoning that is not supported by evidence; the inheritance of attributes in class hierarchies; and inheritance of contexts in part-whole hierarchies. There is also potential in the system for spatial reasoning, and for what-if reasoning.

4. *Versatility in the representation and processing of several kinds of AI-related knowledge* including: the syntax of natural languages; class-inclusion hierarchies (with or without cross classification); part-whole hierarchies; discrimination networks and trees; if-then rules; entity-relationship structures; relational tuples, and concepts in mathematics, logic, and computing, such as 'function', 'variable', 'value', 'set', and 'type definition'.

5. *The seamless integration of diverse aspects of intelligence, and diverse kinds of knowledge, in any combination.* This is because those several aspects of intelligence and several kinds of knowledge all flow from a single coherent and relatively simple source: the SP-multiple-alignment framework.

*It appears that this kind of seamless integration is **essential** in any artificial system that aspires to the fluidity and adaptability of human-like broad intelligence.*

6. *All the AI features of the SPS, detailed above, are likely to be relevant to an understanding of human learning, perception, and cognition.*

7. *The SPS has things to say about neuroscience* in: "Information compression, multiple alignment, and the representation and processing of knowledge in the brain" (PDF, *Frontiers in Psychology*, 7, 1584, 2016, bit.ly/2esmYyt).

8. Somewhat unexpectedly *the SPS provides a radical alternative to existing ideas about the foundations of mathematics* in: "Mathematics as information compression via the matching and unification of patterns," *Complexity*, vol. 2019, Article ID 6427493, 25 pages, 2019, DOI: doi.org/10.1155/2019/6427493 (PDF, bit.ly/2LqUHIr).

9. Apart from the bioinformatics concept of `multiple sequence alignment', an inspiration for the research is evidence for the importance of information compression (IC) in human learning, perception, and cognition: "Information compression as a unifying principle in human learning, perception, and cognition," *Complexity*, vol. 2019, Article ID 1879746, 38 pages, 2019, *DOI:* doi.org/10.1155/2019/1879746 (PDF: bit.ly/2GdIqnY).

10. *The SPS is also relevant to several different areas of application:*

o *Development of intelligence in autonomous robots:* "Autonomous robots and the SP Theory of Intelligence" (PDF, *IEEE Access*, 2, 1629-1651, 2014, bit.ly/18DxU5K).

o *The management of big data:* "Big data and the SP Theory of Intelligence" (PDF, *IEEE Access*, 2, 301-315, 2014, bit.ly/2qfSR3G).

o *Intelligent databases:* "Towards an intelligent database system founded on the SP theory of computing and cognition" (PDF, *Data & Knowledge Engineering*, 60, 596-624, 2007, bit.ly/1CUldR6).

o *Medical diagnosis:* "Medical diagnosis as pattern recognition in a framework of information compression by multiple alignment, unification and search" (PDF, *Decision Support Systems*, 42, 608-625, 2006, bit.ly/1F366o7).

o *The SPS has things to say about natural vision and artificial vision:*

§ "Application of the *SP Theory of Intelligence* to the understanding of natural vision and the development of computer vision" (PDF, *SpringerPlus*, 3(1), 552-570, 2014, DOI: 10.1186/2193-1801-3-552, tinyurl.com/34tkmx8j).

§ "The potential of the SP system in machine learning and data analysis for image processing," (PDF, *Big Data and Cognitive Computing*, 5(1), p. 7, 2021, DOI: 10.3390/bdcc5010007, tinyurl.com/fjsp2n8x).

o *The SPS has things to say about sustainability in computing:* "How the SP system may promote sustainability in energy consumption in IT systems" (PDF, *Sustainability* 2021, 13 (8), article number 4565, https://doi.org/10.3390/su13084565, tinyurl.com/2ccs5z3b).

o *The SPS provides transparency in computing via an audit trail for all its processing and via transparency in all its knowledge structures:* "Transparency and granularity in the SP Theory of Intelligence and its realisation in the SP Computer Model" (PDF, tinyurl.com/2f5hca8d, Published in the book *Interpretable Artificial Intelligence: A Perspective of Granular Computing*, Witold Pedrycz and Shyi-Ming Chen (editors), Springer: Heidelberg, 2021, ISBN 978-3-030-64948-7, DOI: 10.1007/978-3-030-64949-4).

In short, the SPS demonstrates versatility in aspects of intelligence via a relatively simple construct—the SP-multiple-alignment concept—and its potential in several areas of application.

The goal now is to create a first version of an **SP Machine**, derived from the SP Computer Model but with high levels of parallel processing and an improved user interface. This will be developed on a workstation with one or more graphics processing units (GPUs) providing many cores.

Software for the SP Machine will be open-source, so that researchers anywhere who may wish to explore what the SP Machine can or cannot do, or to develop the system further, may create clones of the SP machine.

NOTES

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2. The SP System is the product of a lengthy programme of research, from about 1987 to the present, with a break between early 2006 and late 2012 when I was engaged full time in environmental campaigning (climate change).

3. A relatively full description of the SP System, and its development and advantages, is in an article with the same title as this press release: *Biochemistry provides inspiration for a new kind of AI* (PDF, tinyurl.com/3vh3hxwe).

4. Since people often ask, the name *SP* derives from *Simplicity* and *Power*. This is because: the SP System is a compression of AI-related observations and concepts; the SP System works entirely via IC; and because IC may be seen as a process that promotes the Simplicity of a body of information, I, whilst retaining as much as possible of I's descriptive and explanatory Power.

5. It is intended that `SP' should be treated as a name, like `IBM' or 'BBC', and not as an abbreviation of Simplicity and Power.

6. Much of this research was conducted with generous support of the *School of Computer Science and Electronic Engineering* in Bangor University, UK.