UNIQUE SELLING POINTS FOR THE SP THEORY OF INTELLIGENCE

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Abstract

The *SP Theory of Intelligence* (SPTI) and its realisation in the *SP Computer Model* (SPCM) have several advantages compared with alternatives. These unique selling points include: several advantages compared with deep neural networks (DNNs) and other AI systems; strengths in modelling aspects of intelligence; strengths in other areas of computing; the powerful concept of *SP-Multiple-Alignment*; the central role of information compression (IC) in the workings of the SP system, in keeping with substantial evidence for the importance of IC in human intelligence; and several more.

1 Introduction

The *SP Theory of Intelligence* (SPTI) and its realisation in the *SP Computer Model* (SPCM), outlined below, are founded on substantial evidence for the importance of information compression (IC) across diverse aspects of intelligence in people and other animals. This area of research was pioneered by Fred Attneave [1, 2], Horace Barlow [3, 4] and Satosi Watanabe [9, 10], and is described fairly fully in [14].[1]

Despite its name, the SPTI should not be seen as a fully-developed theory of human-level intelligence, aka Artificial General Intelligence (AGI). Instead, it should be seen as a *foundation* that may be developed towards AGI, beginning with developments described in [6].

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[1] In the rest of this article, references to the SPTI should be understood to include references to the SPCM.

1.1 Outline of the SPTI

The most comprehensive description of the SPTI and SPCM[2] is in the book [11]. A shortened version of the book is described in [13]. And a nearly-complete tutorial about the SPTI with related research up to 2025 is in [18].

The SPTI is conceived as a brain-like system as shown schematically in Figure 1, with *New* information (green) coming in via the senses (eyes and ears in the figure), and with some or all of that information compressed and stored as *Old* information (red), in the brain.

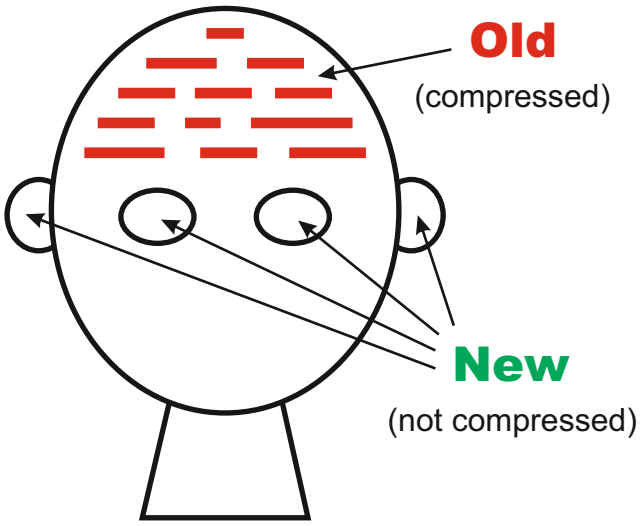

Figure 1: Schematic representation of the SPTI framework. Reproduced from Figure 1 in [13].

In the SPTI, all kinds of knowledge are represented by *SP-Patterns*, where an SP-Pattern is an array of *SP-Symbols* in one or two dimensions. An SP-Symbol is simply a mark from an alphabet of alternatives where each SP-Symbol can be matched in a yes/no manner with any other SP-Symbol. An SP-Symbol does not have any hidden meaning, such as 'add' for the SP-Symbol '+' in arithmetic, or 'multiply' for the SP-Symbol '×', and so on. Any meaning attaching to an SP-Symbol is provided by one or more other SP-Symbols with which it is associated.

A key to the versatility of the SPTI in the representation and processing of diverse aspects of intelligence, diverse kinds of knowledge, and six different techniques for IC, is the powerful concept of SP-Multiple-Alignment. An example of a structure created by the SP-Multiple-Alignment process is shown in Figure 2.

[2]References to the SPTI below may be understood to include the SPCM.

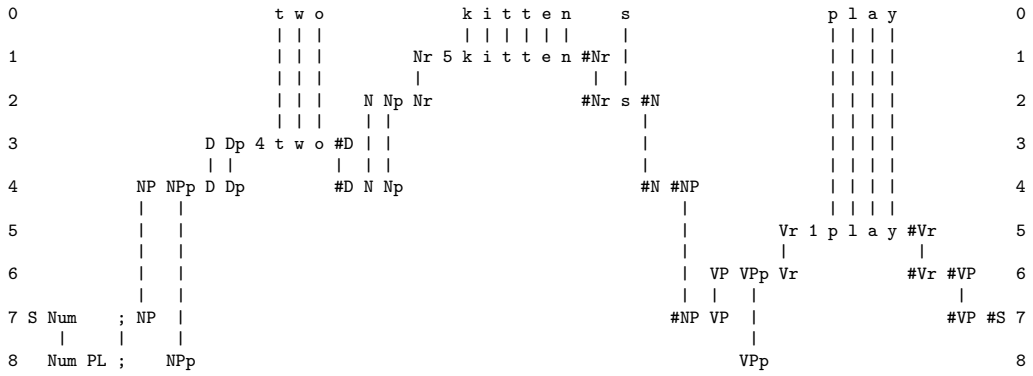

Figure 2: The best SP-multiple-alignment created by the SPCM with a store of Old SP-patterns like those in rows 1 to 8 (representing syntactic structures, including words) and a New SP-pattern, '`t w o k i t t e n s p l a y`', shown in row 0, representing a sentence to be parsed. The SP-pattern in row 8 shows the 'discontinuous' connection between the plural subject of the sentence (marked with '`NPp`') and the plural main verb (marked with '`VPp`'). Adapted from Figure 1 in [12], with permission.

2 Unique selling points for the SPTI

As a foundation for the development of AGI, the SPTI has many advantages compared with other AI systems, advantages which are described in unique selling points (USPs) within a book-length tutorial about the SPTI ([18, Section 2]. Those USPs are summarised in the subsections that follow.

2.1 Simplicity and Power

Although the SPTI is not trivially simple, it provides great *Simplicity* in comparison with its substantial descriptive and explanatory *Power* relating to intelligence and beyond. Hence the name 'SP'.

2.2 The adoption of a top-down research strategy

An advantage for the SPTI is that it has been developed with a top-down research strategy, with substantial advantages compared with the very much more popular bottom-up strategy as described in [18, Appendix C].

In this connection, the SPTI goes some way towards meeting the following criticism of AI research:

> The central problem, in a word: current AI is *narrow*; it works for particular tasks that it is programmed for, provided that what it encoun-

> ters isn't too different from what it has experienced before. That's fine for a board game like Go—the rules haven't changed in 2,500 years—but less promising in most real-world situations. Taking AI to the next level will require us to invent machines with substantially more flexibility. ... To be sure, ... narrow AI is certainly getting better by leaps and bounds, and undoubtedly there will be more breakthroughs in the years to come. But it's also telling: AI could and should be about so much more than getting your digital assistant to book a restaurant reservation. [5, pp. 12–14] (emphasis in the original)

2.3 Advantages of the SPTI compared with deep neural networks

The popularity of deep neural networks (DNNs) make them the main competitors for the SPTI. But the SPTI has several advantages compared with DNNs, described in [18, Section 8.1.10], drawing on the peer-reviewed article [17, Sections 2 to 21]. A selection of the most striking of those advantages are featured amongst the other advantages outlined below.

2.4 Intelligence-related strengths of the SPTI

Intelligence-related strengths of the SPTI are described most fully in [11, Chapters 5–9], more briefly in [13, Sections 5–12] and yet more briefly in [18, Section 8.1].

2.5 Other strengths of the SPTI

Strengths of the SPTI in areas that are less closely related to the modelling of intelligence are summarised in [18, Section 8.2].

2.6 The SP-Multiple-Alignment concept

The powerful concept of *SP-Multiple-Alignment* within the SPTI ([18, Section 5.3]) is largely responsible for the versatility of the SPTI in AI-related and other areas, as summarised in [18, Section 8.1] and [18, Section 8.2] .

Although the concept of SP-Multiple-Alignment was inspired originally by the bioinformatics concept of 'multiple sequence alignment', several years' work were needed to develop the SP-Multiple-Alignment concept and to test it across diverse aspects of human intelligence and beyond.

It is no exaggeration to say that *the SP-Multiple-Alignment concept is a* **major discovery** *with the potential to be as significant for an understanding of intelli-*

gence as is DNA for an understanding of biology. It may prove to be the 'double helix' of intelligence!

2.7 IC is central in the workings of the SPTI

As noted in the Introduction, a foundation for much of the SPTI research is substantial evidence, described in [14], for the importance of IC across diverse aspects of intelligence in people and other animals.

The SPTI is, arguably, the most fully-developed theory of intelligence that recognises the importance of IC across *diverse* aspects of natural intelligence and, by conjecture, *all* aspects of intelligence.

2.8 The SPTI, IC, mathematics, logic, and computing

Associated with the SPTI is a second major discovery: *that much of mathematics, perhaps all of it, may be understood as a set of techniques for IC, and their application [15].* From that conclusion, it is a relatively small step to the conclusion that IC may be seen to provide a foundation for logic and computing [15, Section 7].

2.9 A potential *New Mathematics* with many potential benefits in science and beyond

On the strength of the observation in Section 2.8, IC provides a foundation for both the SPTI and mathematics, and that shared foundation suggests the possibility of creating a *New Mathematics* from an integration of the SPTI with mathematics, with many potential benefits.

Some of the potential benefits of this kind of this kind of association of the SPTI with mathematics are described in [15, Section 9].

2.10 The SPTI and probabilities

In keeping with the close connection between IC and concepts of probability in Solomonoff's Algorithmic Probability Theory (APT) [7, 8], there is an absolute and a relative probability associated with every SP-Multiple-Alignment structure created by the SPTI.

Apart from its strengths as a theory of human intelligence and AI, the SPTI has potential as a theory of probabilities, with potential benefits.

2.11 Seamless integration of diverse aspects of intelligence and diverse kinds of knowledge, in any combination

With respect to the development of AGI, an important strength of the SPTI is how it supports the seamless integration of diverse aspects of intelligence and diverse kinds of knowledge, in any combination [18, Section 2.10].

This strength, which arises from the provision of a single versatile framework (SP-Multiple-Alignment) for diverse aspects of intelligence and diverse kinds of knowledge, appears to be *essential* in any theory of AI that aspires to model the fluidity and versatility of human-level intelligence.

2.12 Transparency in the organisation and workings of the SPTI

The SPTI, via an audit trail for all its workings, provides transparency in how it works [16]. And there is transparency in the way the SPTI structures its knowledge (*ibid.*).

These features, which contrast sharply with, for example, the lack of transparency in the workings of DNNs and how their knowledge is stored, are likely to prove useful in, for example, the analysis of whether or not, or how, the SPTI may have contributed to an accident.

2.13 Modest demands for data and for computational resources

By contrast with the huge demands for data and for computational resources by DNNs, there is clear potential in the SPTI for much smaller demands for those things [17, Section 9].

2.14 Generalisation, over-generalisation, and under-generalisation

The SPTI conceptual framework suggests that remarkably simple principles govern the phenomena of generalisation, and the correction of over- and under-generalisations [18, Section 2.13]. This analysis is indebted in part to Solomonoff's APT [18, Appendix E].

2.15 In unsupervised learning, reducing or eliminating the corrupting effect of errors in data

How, in unsupervised learning, the SPTI may reduce or eliminate the corrupting effect of 'dirty data' is described in [18, Section 5.7.5]. This analysis appears to be

unique to the SPTI.

2.16 How to learn usable knowledge from a single exposure or experience

Like people, the SPTI can learn usable knowledge from a single exposure or experience [17, Section 7]. This contrasts sharply with the large quantities of data and large computational resources that are needed by DNNs before data is ready for use.

3 Conclusion

The unique selling points outlined in this report, with other advantages of the SPTI described in [17], suggest that the SPTI provides a relatively firm foundation for the development of AGIs which is stronger than any DNN or other alternative.

Possible first steps in the further development of the SPTI are described in [6], and shown schematically in Figure 3 with potential applications.

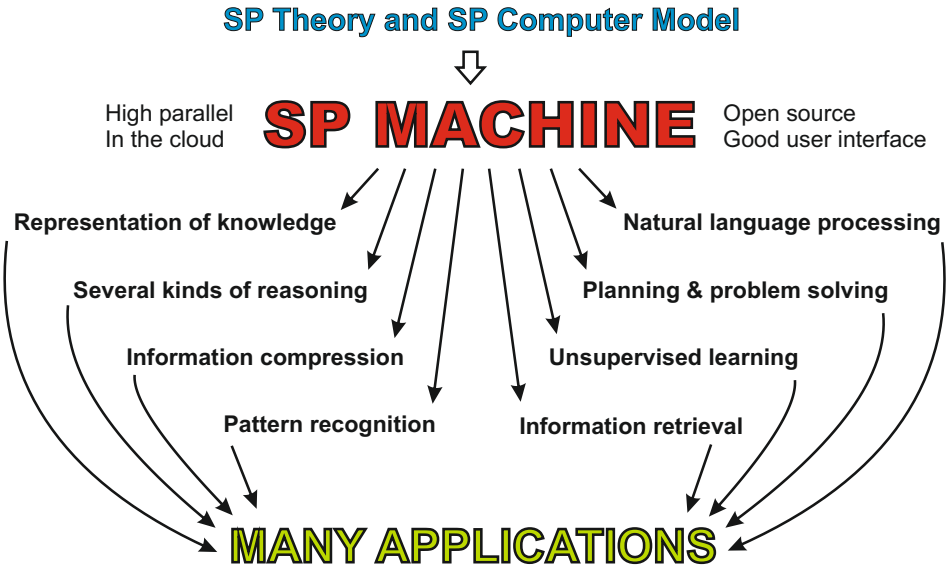

Figure 3: Schematic representation of the development and application of the proposed SP machine. Reproduced from Figure 2 in [13].

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