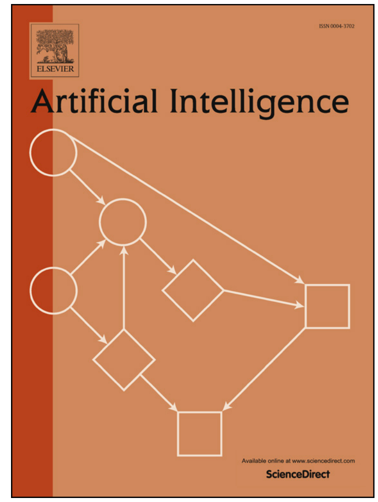

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A Computational Framework for Conceptual Blending

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Abstract

We present a computational framework for *conceptual blending*, a concept invention method that is advocated in cognitive science as a fundamental and uniquely human engine for creative thinking. Our framework treats a crucial part of the blending process, namely the generalisation of input concepts, as a search problem that is solved by means of modern answer set programming methods to find commonalities among input concepts. We also address the problem of pruning the space of possible blends by introducing metrics that capture most of the so-called *optimality principles*, described in the cognitive science literature as guidelines to produce meaningful and serendipitous blends. As a proof of concept, we demonstrate how our system invents novel concepts and theories in domains where creativity is crucial, namely mathematics and music.

Keywords: *computational creativity, conceptual blending, cognitive science, answer set programming*

1. Introduction

Creativity is an inherent human capability that is crucial for the development and invention of new ideas and concepts [3]. This paper addresses a kind of creativity which Boden [3] calls *combinational*, and which has been studied by Fauconnier and Turner [27] in their framework of *conceptual blending*. In brief, conceptual blending is a process where one invents a novel concept, called the *blend*, by combining two familiar input concepts. For illustration, consider the classical example of blending the concepts *house* and *boat* (e.g. [34, 27]). A possible result is the invention of a *house-boat* concept, where the medium on which a house is situated (land) becomes the medium on which boat is situated (water), and the inhabitant of the house becomes the passenger of the boat. Another possible blend is the *boat-house*, where the boat 'inhabits' the house.

An inherent computational problem of conceptual blending is to find a common ground, called *generic space*, between the two input concepts [27]. For example, the *house-boat* blend has the generic space of a person being inside an object that is not situated on any medium (or that is situated on a more general medium). Once the generic space has been identified, one can develop possible blends by specialising the generic space with elements from the input concepts in a meaningful way. However, this is not trivial because the naive union of input spaces can lead to inconsistencies. For example, the medium on which an object is situated can not be land and water at the same time. Hence, before combining the input concepts, it is necessary to generalise at least one medium assignment. Another problem is the huge number of possible blends, which are often not meaningful. For example, blending *house* and *boat* such that the house becomes the passenger of the boat – imagine a house-transporting cargo vessel – is not very convincing. Consequently, one has to prune the search space by ruling out such low-quality blends.

Conceptual blending is perceived as a milestone in human cultural development [27]. The main motivation behind blending from an AI perspective is to find a computational interpretation of the human blending process, which could be an equally important milestone in the development of intelligent agents and autonomous systems. The value of conceptual blending for the development of creative systems has been witnessed by several works in the field of Artificial Intelligence and cognitive science, where particular implementations of this cognitive theory have been proposed [83, 63, 64, 33, 36].

As we show in our survey in Sec. 5, existing approaches propose computational characterisations of conceptual blending by using different formal representations for the input spaces and different techniques for performing the blending operation, and for the evaluation of the blends. For instance, Goguen and Harrell [33] logically formalise conceptual blending in terms of algebraic theories, Pereira [64] uses concept maps and frames, and rules and constraints to implement blend evaluation, while Veale and

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